Bartree

JOURNAL OF ANIMAL SCIENCE

Published Quarterly

by the

American Society of Animal Production

NOVEMBER

1960

Volume 19 Number 4

Editorial Board

W. D. GALLUP, *Editor and Chairman* — A. B. CHAPMAN, *Associate Editor*

C. E. TERRILL, *Business Manager*

E. E. BARTLEY (1962) *
D. E. BECKER (1963)
R. O. BERRY (1961)
L. J. BRATZLER (1960)
DOYLE CHAMBERS (1961)
G. K. DAVIS (1962)
R. H. DUTT (1963)
K. E. GREGORY (1963)
W. P. LEHRER, JR. (1962)
G. P. LOFGREEN (1960)
T. W. PERRY (1961)
R. W. SWIFT (1960)

* Terms expire on December 31 of years indicated.

Officers of the American Society of Animal Production

J. K. LOOSLI, *President*
H. H. STONAKER, *Vice President*
C. E. TERRILL, *Secretary-Treasurer*
W. P. GARRIGUS, *Director*
W. W. GREEN, *North-Atlantic Vice President*
J. A. WHATLEY, *Southern Vice President*
G. P. LOFGREEN, *Western Vice President*

Subscriptions. Correspondence concerning subscriptions, purchase of single copies and back issues and related business should be addressed to the business manager, C. E. Terrill, Animal Husbandry Research Division, Agricultural Research Center, Beltsville, Maryland. Subscription price for non-members for Volume 19 (1960) is $7.00 in U. S. and Canada, $7.50 in rest of North and South America, and $8.00 in other places. Checks should be made payable to the American Society of Animal Production. Foreign subscribers are requested to remit by International money order or by a draft on a New York bank.

Address Change. Notice of change in address should be received by the business manager at least 40 days previous to month of Journal issue. Lost copies, owing to change in address, cannot be supplied unless adequate notice has been given.

Missing Copies. Claims for missing copies should be sent to the business manager within 90 days of publication date. Such claims will be allowed only if the Journal or the printing company is at fault.

Membership. Application is invited from persons with interest in animal science and livestock production. The vice president of the Society is chairman of the Membership Committee. Annual dues in the Society which include a subscription to the Journal are $6.00 in U. S. and Canada, $6.50 in rest of North and South America and $7.00 in other countries.

Manuscripts. Address manuscripts and correspondence concerning them to the editor, W. D. Gallup, Department of Biochemistry, Oklahoma State University, Stillwater, Oklahoma. At least one of the authors of a manuscript should be a member of the Society. Publication of papers by non-members requires the approval of the Executive Committee. See "Information to Contributors" regarding manuscript preparation.

Reprints. Reprints of papers in the Journal are obtainable only from the authors or their institutions. Authors of papers accepted for publication are required to make a minimal purchase of 100 reprints.

News and Notes. Announcements about meetings, personnel changes and other items of interest to the Society may be sent directly to the editor. Similar items relating to the USDA and Federal Agencies are received from James O. Grandstaff, State Experiment Stations Division, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

Second class postage paid at Albany, N. Y.

Boyd Printing Company, Inc., 49 Sheridan Ave., Albany 10, N. Y.

Journal of

ANIMAL SCIENCE

VOLUME 19 NOVEMBER, 1960 NUMBER 4

CONTENTS

Page

Effect of Recovery Interval of Irrigated Forage on the Performance of Grazing Steers. J. L. Hull, J. H. Meyer and G. P. Lofgreen.. 981

Effects of Stilbestrol in Altering Carcass Composition and Feed Lot Performance of Beef Steers. M. L. Ogilvie, E. C. Faltin, E. R. Hauser, R. W. Bray and W. G. Hoekstra..... 990

Effects of Pig Growth Hormone on Pigs. B. Henricson and S. Ullberg 1002

Effects of Level of 3, 3′ Diallylhexestrol on Steer Performance and Carcass Characteristics. I. A. Dyer, E. E. Rupnow and W. E. Ham 1009

Estimation of Carcass Merit of Swine from Live Animal Measurements. O. W. Robison, J. H. Cooksey, A. B. Chapman and H. L. Self..... 1013

Swine Selection Indexes Including Live Animal Measurements as Indicators of Carcass Merit. O. W. Robison, A. B. Chapman and H. L. Self..... 1024

Effect of Size of Grind and Level in the Ration of Dehydrated Alfalfa Meal, of Trace Minerals and an Implanted Tranquilizer on the Performance of Fattening Lambs. T. W. Perry, R. C. Holz, W. H. Smith, W. M. Beeson and M. P. Plumlee..... 1031

Measurement of and Ways of Affecting Sex-Influenced Performance of Growing-Finishing Swine. V. R. Cahill, H. S. Teague, L. E. Kunkle, A. L. Moxon and E. A. Rutledge..... 1036

Diethylstilbestrol, Oxytetracycline, Linseed Oil Meal, Soybean Oil Meal and Levels of Corn Silage in Cattle Fattening Rations. O. E. Kolari, A. L. Harvey, J. C. Meiske, W. J. Aunan and L. E. Hanson..... 1041

Effect of Energy Level on the Protein Requirement of Lambs Fattened With and Without Stilbestrol. J. R. Jones and D. E. Hogue 1049

Ratios of Dried Skimmilk and Dried Whey for Pig Starter Rations. D. M. Danielson, E. R. Peo, Jr. and D. B. Hudman..... 1055

Influence of Year and Season of Birth, Sex, Sire, and Age of Dam on Weights of Beef Calves at 60, 120, 180 and 240 Days of Age. C. J. Brown..... 1062

Page

Influence of Mineral Supplements on the Growth of Calves, Digestibility of the Rations and Intra-Ruminal Environment. J. W. G. Nicholson, J. K. Loosli and R. G. Warner 1071

Effect of Semen Volume and Number of Sperm on Fertility and Embryo Survival in Artificially Inseminated Gilts. Frederick W. Stratman and H. L. Self 1081

Increased Feedlot Bloat from Feeding Soybean Oil in a Mixed Ration to Steers. C. J. Elam, J. Gutierrez and R. E. Davis 1089

Studies with the Cellulolytic Fraction of Rumen Bacteria Obtained by Differential Centrifugat[illegible] Burk A. Dehority, Khaled el-Shazly and Ronald R. Jo[illegible] 1098

Effect of Feeding Tranquilize[illegible] Growing and Finishing Swine. R. A. Pickett, J. H. Cor[illegible] W. M. Beeson 1110

Effect of Level of Dietary [illegible]antothenic Acid and Protein on Performance of Growi[illegible]attening Swine. W. G. Pond, E. Kwong and J. K. Loosli 1115

A Proposed Method for Removing Sources of Error in Beef Cattle Feeding Experiments. J. H. Meyer, G. P. Lofgreen and W. N. Garrett 1123

Use of Progesterone and Estrogen in the Control of Reproductive Activities in Beef Cattle. L. C. Ulberg and C. E. Lindley 1132

Some Variation in Estrogenic Activity in Fresh and Dried White Clover Clones and the Ladino Variety. E. M. Bickoff, A. L. Livingston, A. N. Booth, C. R. Thompson, E. A. Hollowell and E. G. Beinhart 1143

Relationship of Feed Intake and Length of Collection Period to Apparent Digestibility of a Self-Fed, Pelleted Lamb Ration. R. B. Grainger, N. Gay and F. H. Baker 1150

High Level Copper for Growing-Finishing Swine. H. D. Wallace, J. T. McCall, Billy Bass and G. E. Combs 1153

Quantitative Estimations of Myoglobin and Hemoglobin in Beef Muscle Extracts. H. P. Fleming, T. N. Blumer and H. B. Craig 1164

Effect of Alfalfa Pasture Bloat on Certain Blood Components of Cattle. L. R. Brown, R. S. Allen, R. H. Johnson and N. L. Jacobson 1172

A Technique for Assay of Goitrogens in Feed. B. N. Premachandra and C. W. Turner 1181

Effect of Temperature upon the Nutritive Value of Artificially Dried Hay. J. W. Bratzler, E. Keck, Jr. and R. R. Yoerger 1186

A Method of Estimating the Percentage of Protein and Fat in the Edible Portion of Steer Carcasses. W. H. Kennick and D. C. England 1190

Effect of Mineral Supplementation on Pork Muscle Color as Measured by Spectrophotometry and Disk Colorimetry. W. E. Henry and L. J. Bratzler 1195

Page

Continuous Versus Intermittent Observations in Behavior Studies with Grazing Cattle. J. L. Hull, G. P. Lofgreen and J. H. Meyer 1204

Effect of Some Controllable Errors on Estimates of Genetic Parameters, with Special Reference to Early Post-Natal Growth in Merino Sheep. G. M. Tallis 1208

Erratum 1215

Abstracts of Papers at Annual National Meeting 1216

Subject Index for Abstracts, National Meeting 1340

Author Index for Abstracts, National Meeting 1346

News and Notes 1351

Subject Index for Volume 19, 1960 1356

Author Index for Volume 19, 1960 1363

EFFECT OF RECOVERY INTERVAL OF IRRIGATED FORAGE ON THE PERFORMANCE OF GRAZING STEERS

J. L. Hull, J. H. Meyer and G. P. Lofgreen

University of California, Davis [1]

SOUND pasture management must consider the requirements of both plant and animal. Few fields of research involve the careful consideration of plant-animal relationships that is required in grazing management. Two of the most important factors that can be controlled in a system of grazing are the length of the grazing period and the length of the regrowth interval.

Peterson and Hagan (1953) concluded from clipping experiments that a forage recovery interval of 25 to 28 days might give the greatest production from a grass-legume irrigated pasture. However, little information involving measurements on both grazing animals and forage is available. The present experiments were designed to provide such information.

Experimental

A uniform field of orchardgrass *(Dactylis glomerata var. Akaroa)* and trefoil *(Lotus tenuis)* was divided into 36 pastures of approximately 0.4 acre each. Trials were conducted in each of the two years 1957 and 1958 beginning in early May in 1957 and early June in 1958. Forage recovery intervals were obtained by varying the number of pastures per treatment—five, six and seven pastures, with each allowed a six-day grazing period, resulting in respective forage recovery intervals of 24, 30 and 36 days. Approximately equal grazing intensity was obtained on all treatments through the use of an adjustable fence forming the end of each pasture.

Management of the forage included adequate irrigation and fertilization, with 30 units of nitrogen (30 lb. of available nitrogen) applied per acre per month. In the spring the forage was harvested by a field chopper the proper number of days prior to the start of grazing to establish the desired recovery intervals for the treatments. The forage removed was not credited to the experiment. At the end of the 1957 experiment, Ladino clover *(Trifolium repens var. latum)* was seeded into the pastures to increase the proportion of legumes since the number of trefoil plants had been reduced.

The 1957 and 1958 experiments were identical except that one group of steers on each recovery interval in 1957 was supplemented with barley. The barley intake was controlled by varying the salt (sodium chloride) level between 8 and 20% in a barley-salt mixture. An attempt was made to obtain an equal intake of barley on each recovery interval. Actual consumption, however, averaged 5.2, 3.9 and 5.5 lb. per steer per day on the 24-, 30- and 36-day recovery intervals, respectively.

[1] Department of Animal Husbandry.

Each year good to choice Hereford feeder steers were obtained 30 days before grazing was to begin so that 18 steers (three per treatment in each replicate) could be gentled and accustomed to fecal collections. All animals were allotted at random to each treatment. Initial weights were taken after the animals had been on pasture 6 days, all weighings being made after 14 hours without feed and water.

Body composition of all steers was calculated at the end of the experiment from specific gravity determinations made on the right half of the carcass. The empty body composition of the whole animal was calculated from the specific gravity by use of equations developed by Kraybill *et al.* (1952) and Reid *et al.* (1955) according to the method outlined in detail by Lofgreen and Otagaki (1960). Corrected carcass and energy yield were

TABLE 1. THE EFFECT OF RECOVERY INTERVAL ON THE LIGNIN, CRUDE PROTEIN AND TOTAL DIGESTIBLE NUTRIENT CONTENT OF TWO DIFFERENT PASTURE MIXTURES [a]

Mixture	Recovery interval	Lignin	Crude protein	TDN
	days	%	%	%
Trefoil-orchardgrass	24	4.1	17.8	66.6
	30	4.1	16.9	65.2
	36	3.8	15.8	63.9
Trefoil-Ladino clover and orchardgrass	24	4.6	17.3	64.4
	30	4.4	17.0	65.1
	36	4.6	16.9	64.0

[a] Dry matter basis.

determined by the method of Meyer *et al.* (1960). Initial body composition was estimated from a representative group of steers slaughtered at the initiation of the trials.

Production of total forage was estimated by the clipping technique and consumption was measured by the chromogen-chromium oxide technique of Reid *et al.* (1952). Before the steers entered a pasture, 5 to 10 areas of 18 sq. ft. each were clipped at random in each pasture. Dry matter and species determinations were made and the samples composited for chemical analysis.

Digestibility and forage consumption were measured at three approximately equal intervals in each experiment. Chromium oxide was administered daily at a level of 20 gm. at 7 a.m. during a preliminary period of 7 days and a collection period of 6 days. Grab samples of feces were collected twice daily from the rectum of the collection steers during the six-day collection period. All results are reported on a silica-free basis because of dust contamination of the forage. The method of Kimura and Miller (1957) was used for the chromium oxide determination. Total digestible nutrients (TDN) were calculated as described by Lofgreen and Meyer (1956).

Behavior studies were made in the 1957 experiment. Observations were made for 24 hours on the first and fifth days of a six-day grazing period in

August. Each lot, in the same order, was checked every 15 minutes and a record made of the numbers of animals grazing, eating supplement, standing and ruminating, standing idle, lying and ruminating, lying idle, and drinking. Total time spent in a given behavior was calculated by assuming that the number of animals observed in a given behavior continued in that

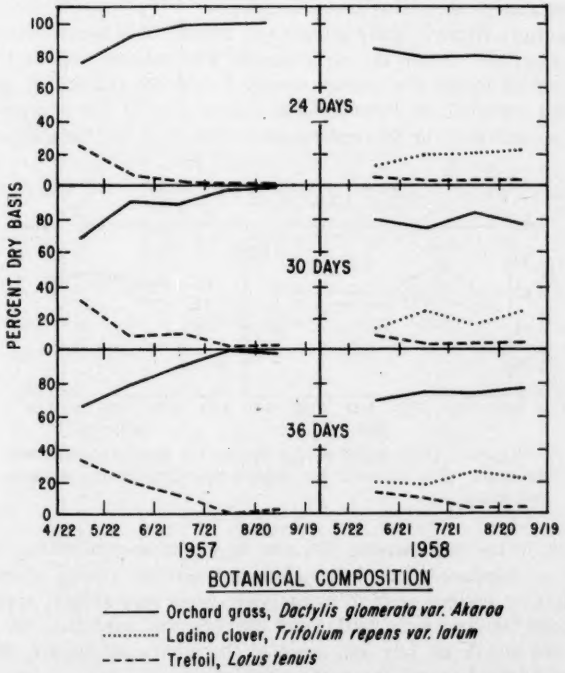

Figure 1. Botanical composition of the forage for the three recovery intervals.

behavior until the next observation. This technique was used in an earlier study (Lofgreen *et al.*, 1957) and has been proven to be valid as a measure of the factors being studied (Hull *et al.*, 1960).

Results and Discussion

The lignin, protein and TDN of the forage are presented in table 1. Protein and TDN decreased only slightly with increasing recovery interval while lignin showed no change.

From the botanical composition of the forage presented in figure 1, it is noted that the persistence of trefoil increased with longer recovery intervals.

As the grazing season progressed, trefoil plants per unit area decreased in all treatments, evidencing that trefoil was a poor competitor under the conditions of these studies. Adding Ladino clover to the pasture in 1958 resulted in a more uniform mixture throughout the season. The forage grazed was always in the vegetative stage. Except for a few plants, trefoil or Ladino clover never flowered, although a few plants of orchardgrass reached the flower stage in the early part of the season.

As shown in figure 2, daily growth was greater with longer recovery intervals, especially during the early season. The seasonal growth trends of daily yield of forage dry matter closely follow the pattern of extensive yield data reported by Peterson and Hagan (1953) for a grass-legume pasture, except that the dry matter production peak for these experiments

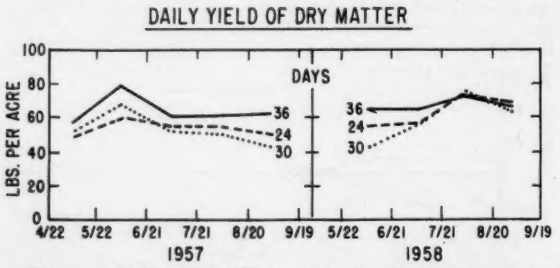

Figure 2. Daily yield of dry matter for the three recovery intervals. (See figure 1 for legend showing botanical composition.)

was later in the 1958 season. Because of environmental differences it is difficult to compare years, but Nelson and Robins (1956) showed that same shift in seasonal peak of forage yield when several light applications of nitrogen fertilizer were used. Since nitrogen was applied to the pasture during the middle of July and again in the middle of August, this could explain the later seasonal dry matter production peaks.

Table 2 contains some the important production data. Although the daily gains are somewhat lower in each experiment on the 36-day recovery interval, this difference was not statistically significant. The increased gain from supplementation was highly significant. The consumption of approximately 5 lb. of barley by steers grazing this pasture resulted in an increased rate of gain of 0.25 lb. per day. This is in good agreement with earlier work from this station in which 5 lb. of a barley and beet pulp mixture stimulated the daily gain of beef steers eating green alfalfa 0.33 lb. per day (Lofgreen *et al.*, 1960). Although the supplemented steers had a higher dressing percent and carcass grade, there was no interaction of supplement and recovery interval, indicating the supplement produced relatively the same effect regardless of the number of days the pasture was

TABLE 2. EFFECT OF RECOVERY INTERVAL AND SUPPLEMENTATION ON DAILY GAINS, FEED CONSUMPTION AND CARCASS GRADE

Item of interest	1957						1958		
	Supplemented			Unsupplemented			Unsupplemented		
Recovery interval of forage, days	24	30	36	24	30	36	24	30	36
Number of animals per treatment	6	7	8	6	7	8	10	12	14
Number of animals per acre	3.5	3.3	3.8	2.8	2.8	2.8	2.3	2.6	2.6
Duration of trial, days	142	142	142	142	142	142	120	120	120
Initial body weight, lb.	634	629	629	642	631	628	541	539	518
Daily body weight gain, lb.	1.88	1.65	1.71	1.52	1.52	1.46	1.61	1.56	1.42
Daily dry matter consumed, lb. per head	....	....	....	22.1	20.3	20.4	20.1	18.6	19.4
Daily TDN consumed, lb. per head	....	....	....	14.7	13.2	13.0	12.9	12.1	12.4
Weight gain per lb. of dry matter, lb.	....	....	....	6.9	7.5	7.2	8.0	8.4	7.3
Dressing percent	60.6	60.8	60.8	58.4	57.7	57.7	53.2	54.2	54.4
Carcass grade, percent of animals in grade:									
Good	67	86	50	0	14	0	0	0	0
Standard	33	14	50	83	86	88	90	100	100
Utility	0	0	0	17	0	12	10	0	0

TABLE 3. EFFECT OF RECOVERY INTERVAL ON PRODUCTION PER ACRE

(Unsupplemented Only)

Item of interest	Recovery interval, days		
	24	30	36
Total live weight gain, lb. per acre	526	541	502
Total dressed weight gain, lb. per acre	324	333	326
Fat in dressed weight gain, percent	25.5	25.7	22.9
Corrected carcass gain, lb. per acre	375	387	353
Energy in live weight gain, mcal.[a] per acre	798	814	696
Energy in dressed weight gain, mcal.[a] per acre	486	502	458
Relative energy gain per acre, percent of 24-day interval	100	103	94

[a] Megacalorie.

allowed to recover. In both years the forage and TDN intake tended to be higher on the 24-day recovery interval than on the 30- and 36-day intervals. These differences, however, were not statistically significant.

Since analysis of the data in table 2 revealed no interactions of year and recovery interval, the effect of recovery interval on production per acre presented in table 3 is based on the means of both years for the unsupplemented treatments. These data cannot be analyzed statistically since only the mean gain per acre for each lot can be calculated. Even though more forage was available per acre on the 36-day recovery interval, there appeared to be a somewhat lowered yield of corrected carcass, adjusted to equal energy and protein content, and energy production. This was due primarily to the lowered fat percentage in the gain produced on this treatment. It may be, therefore, that with the type of pasture studied in these experiments, a 36-day recovery period is approaching that interval which will allow the forage to become too mature for optimum utilization. This, however, cannot be conclusively proven from these studies.

The over-all effects of supplementation on production per acre in 1957 are shown in table 4. Because there was no interaction of recovery interval

TABLE 4. THE EFFECTS OF SUPPLEMENTATION ON PRODUCTION PER ACRE IN 1957 STUDY

Item of interest	Unsupplemented	Supplemented
Total live weight gain, lb. per acre	595	881
Total dressed weight gain, lb. per acre	380	647
Dressed weight gain as percent of live weight gain	63.9	73.4
Fat in dressed weight gain, percent	21.9	33.1
Corrected carcass gain, lb. per acre	401	888
Energy in live weight gain, mcal.[a] per acre	821	1593
Energy in dressed weight gain, mcal.[a] per acre	521	1152

[a] Megacalorie.

and supplement all recovery intervals are combined in these data. The consumption of approximately 5 lb. of barley per head per day or 19 lb. per acre per day resulted in an increase in live beef production of 48%. The dressed beef, however, increased 70%. The dressing percent of the unsupplemented steers was 57.9, whereas the supplemented steers dressed 60.7% (table 2). The dressed weight gain as percent of live weight gain for the two treatments was, however, 63.9 and 73.4%, respectively. A greater proportion of the gain produced from the supplement was therefore distributed in that part of the body retained at slaughter than in the discarded offal.

Because of the difference in the fat content of the gain and the dressing percent, a more valid measure of the effect of treatment is the gain in

TABLE 5. CALCULATION OF THE NET ENERGY OF THE UNSUPPLEMENTED FORAGE

	1957			1958		
Recovery interval, days	24	30	36	24	30	36
NE required for maintenance, mcal.[a] per acre	1965	1966	1946	1227	1351	1309
Energy in body weight gain, mcal.[a] per acre	939	806	719	656	822	673
Total NE, mcal.[a] per acre	2915	2772	2665	1883	2173	1982
Forage dry matter consumed, lb. per acre	8788	8085	8042	5550	5701	5947
NE in forage, mcal.[a] per 100 lb. dry matter	33.2	34.3	33.1	33.9	38.1	33.3
TDN in forage, lb. per 100 lb. dry matter	66.6	65.2	63.9	64.4	65.1	64.0
NE per lb. of TDN, mcal.[a]	0.50	0.53	0.52	0.53	0.59	0.52

[a] Megacalorie.

corrected carcass (Meyer *et al.*, 1960). Such a measure places the carcass gains on an equal energy and protein basis. The consumption of the supplement resulted in an increase in corrected carcass and in energy of 120% over the production without supplement. Supplementation, therefore, resulted in an increased body weight gain, but possibly more important was the deposition of a greater proportion of the gain in the dressed weight and the deposition of a higher energy gain.

The net energy (NE) of the unsupplemented forage can be estimated from the energy required for maintenance, the energy gain and the forage consumption. The maintenance requirement can be estimated from the equation of Garrett *et al.* (1959) and used with the experimentally measured energy gain and forage consumption. The data are presented in table 5. It is again demonstrated that there is little difference in the value of the forage consumed on the three recovery intervals. It is noteworthy that even though the TDN in the dry matter was relatively high, the NE was low. The mean value of 0.53 megacalories (mcal.) of NE per pound of TDN is what one would expect in a rather low-quality roughage. In earlier studies (Lofgreen *et al.*, 1960) green alfalfa fed to beef steers contained 0.75 and 0.83 mcal. of NE per pound of TDN.

It is possible to estimate the NE value of the barley fed to the supplemented lots if it can be assumed that grazing intensity was equal in the

TABLE 6. CALCULATION OF THE NET ENERGY OF THE BARLEY SUPPLEMENT

Item of interest	Unsupplemented	Supplemented
NE required for maintenance, mcal.[a] per acre	1963	2530
Energy in body weight gain, mcal.[a] per acre	821	1593
Total NE, mcal.[a] per acre	2784	4123
NE from barley supplement, mcal.[a]	....	1339
Barley dry matter consumed, lb. per acre	....	2229
NE of the barley, mcal. per 100 lb. dry matter	....	60.1

[a] Megacalorie.

supplemented and unsupplemented lots. An effort was made to accomplish this by reducing the area available to the supplemented animals so that the forage remaining after grazing appeared to be comparable. Recognizing this technique is subject to the accuracy of the eye in estimating grazing intensity, the data resulting from the assumption of equal grazing intensity are presented in table 6. The value of 60.1 mcal. of NE per 100 lb. of barley dry matter, although low, is in line with the low NE of the forage and indicates that the steers in these studies made inefficient use of the digestible nutrients in both the forage and the barley. This re-emphasizes the importance of using the net energy principle in pasture investigations as earlier work from this station has suggested.

Behavior studies often prove useful in interpretation of results when combined with production data. The results of behavior observations made

TABLE 7. BEHAVIOR OF STEERS IN 1957 STUDY

Behavior	Unsupplemented	Supplemented
	Time spent per day, hours	
Grazing:		
First day	8.8	7.5
Fifth day	10.0	7.0
Means	9.4	7.3
Eating supplement:		
First day	0	0.4
Fifth day	0	1.4
Means	0	0.9
Ruminating:		
First day	7.8	7.7
Fifth day	7.2	6.2
Means	7.5	7.0
Idling:		
First day	7.6	8.2
Fifth day	6.4	9.0
Means	7.0	8.6

during the 1957 studies are presented in table 7. Since there were no differences among recovery intervals, all are combined in presentation of the data. As one would expect, the unsupplemented animals spent more time grazing than those supplemented with barley. This difference was highly significant. When the time spent eating supplement is added to the grazing time, the total time spent eating by the supplemented steers is still less than those receiving no supplement. It is of interest to note that the supplemented animals spent 3.5 times as much time eating supplement the fifth day in the field as on the first day. This difference was statistically significant. This undoubtedly resulted in a greater barley consumption although only total consumption for the period was obtained. The extra time spent grazing by the unsupplemented animals was spent idling by those receiving barley. One might speculate that this difference in activity might tend to magnify slightly the differences in production between these two groups.

Summary

During two seasons studies were made of the performance of beef steers grazing on irrigated grass-legume pasture at different stages of maturity. The maturity stages were controlled by allowing 24, 30 and 36 days for the forage to recover between six-day grazing periods. A study of the effects of barley supplementation was made during the first season.

The data indicated that the forage was grazed when in a vegetative stage. No large differences were noted in TDN, crude protein and lignin content of the grazed forage. Recovery interval did not influence steer response as measured by daily gain, feed consumption, efficiency of feed utilization, live weight, dressed weight or energy gain per acre or in animal behavior. A barley supplement increased daily gains, caused a greater proportion of gain to be distributed in the dressed weight and resulted in deposition of a higher energy gain.

Unsupplemented animals spent more time grazing and less time idling than those receiving a barley supplement. Supplemented steers spent 3.5 times as much time eating supplement during the fifth day in a pasture as during the first day.

The net energy of the forage and the barley supplement, determined from energy gains and estimated maintenance requirements, averaged 33.5 and 60.1 mcal. per 100 lb. dry matter, respectively.

It appears that when the type of forage studied in these trials is grazed at a vegetative stage, factors other than animal response will determine rotational intervals within 24 to 36 days.

Literature Cited

Garrett, W. N., J. H. Meyer and G. P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J. Animal Sci. 18:528.

Hancock, J. J. 1950. Grazing habits of dairy cows in New Zealand. Emp. J. Agr. 18:72.

Hull, J. L., G. P. Lofgreen and J. H. Meyer. 1960. Continuous vs. intermittent observations in behavior studies with grazing cattle. J. Animal Sci. 19:1204.

Kimura, F. T. and V. L. Miller. 1957. Improved determination of chromic oxide in cow feed and feces. Agr. and Food Chem. 5:216.

Kraybill, H. F., H. L. Better and O. G. Hankins. 1952. Determination of fat and water content from measurement of body specific gravity. J. Appl. Physiol. 4:575.

Lofgreen, G. P. and J. H. Meyer. 1956. A method for determining total digestible nutrients in grazed forage. J. Dairy Sci. 39:268.

Lofgreen, G. P., J. H. Meyer and J. L. Hull. 1957. Behavior patterns of sheep and cattle being fed pasture or soilage. J. Animal Sci. 16:773.

Lofgreen, G. P. and K. K. Otagaki. 1960. The net energy of blackstrap molasses for fattening steers as determined by a comparative slaughter technique. J. Animal Sci. 19:392.

Lofgreen, G. P., J. H. Meyer and N. R. Ittner. 1960. Effects of time and level of supplementation on beef steers fed alfalfa soilage or hay. J. Animal Sci. 19:156.

Meyer, J. H., G. P. Lofgreen and W. N. Garrett. 1960. A proposed method for removing sources of error in beef cattle feeding trials. J. Animal Sci. 19:1123.

Nelson, C. E. and J. S. Robins. 1956. Some effects of moisture, nitrogen fertilizer and clipping on yield and botanical composition of Ladino clover-orchardgrass pasture under irrigation. Agron. J. 48:99.

Peterson, M. L. and R. M. Hagan. 1953. Production and quality of irrigated pasture mixtures as influenced by clipping frequency. Agron. J. 45:283.

Reid, J. T., P. G. Woolfolk, W. A. Hardison, C. M. Martin, A. L. Brundage and R. W. Kaufman. 1952. A procedure for measuring the digestibility of pasture forages under grazing conditions. J. Nutr. 46:255.

Reid, J. T., G. H. Wellington and H. O. Dunn. 1955. Some relationships among the major chemical components of the bovine body and their application to nutritional investigations. J. Dairy Sci. 38:1344.

EFFECTS OF STILBESTROL IN ALTERING CARCASS COMPOSITION AND FEED LOT PERFORMANCE OF BEEF STEERS [1, 2, 3]

M. L. OGILVIE, E. C. FALTIN, E. R. HAUSER, R. W. BRAY AND W. G. HOEKSTRA

University of Wisconsin,[4] Madison

Introduction

INCREASED rate of body weight gain and improved feed efficiency of steers receiving stilbestrol either implanted or fed orally, has been demonstrated repeatedly. However, there remains some question as to the quality of carcasses from treated steers in comparison to those from untreated controls. In evaluating the influence of stilbestrol on carcass composition most investigators have analyzed the 12th rib section (Beeson *et al.*, 1956; Andrews *et al.*, 1956) or the 9–10–11 rib section (Kastelic *et al.*, 1956; Deans *et al.*, 1956). Thus the rib has been used as an indication of total carcass composition; however, the validity of this has not been demonstrated for stilbestrol treated animals.

Summary of the published data would indicate that stilbestrol usually increased the percent protein or separable lean in the rib and caused a reduction in percent fat. These changes in carcass composition have not been studied at intervals throughout the feeding period. Also, the relative efficiencies of stilbestrol-treated and untreated steers in converting dietary energy and protein into carcass energy and protein has not been investigated, although Preston and Gee (1957) have made this experimental approach with lambs implanted with hexestrol.

The experiments reported in this paper were initiated to study the effects of orally administered stilbestrol in amounts of 0, 10, and 30 mg./steer/day on feed lot performance, carcass characteristics, efficiency of energy and protein conversion, and total carcass composition. These effects were studied periodically during a 168-day fattening trial.

Procedure

The experiment consisted of two trials conducted during the May–November periods of 1956 and 1957.

Forty yearling Hereford steers averaging about 560 lb. were purchased for each trial. After allotment to outcome groups based on weight, condi-

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station, Madison.

[2] The authors wish to express their appreciation to Dr. P. H. Phillips for his assistance and advice during the course of the experiment.

[3] Acknowledgement is made to Chas. Pfizer and Co., Terre Haute, Ind. and to Eli Lilly Co., Indianapolis 6, Ind. for contributing the stilbestrol used in this experiment.

[4] Departments of Animal Husbandry and Biochemistry, Madison.

tion, and grade, the steers were randomly assigned to three lots of 12 steers each: Lot I, control; Lot II, 10 mg.; and Lot III, 30 mg. stilbestrol/steer/day.

The experimental ration consisted of a grain mixture composed of 80% shelled corn and 20% oats; medium quality, mixed legume-grass hay; and, soybean oil meal. Each lot received 2 lb. of soybean oil meal/steer/day which contained the stilbestrol for the treated lots, and was allowed the ground grain mixture and hay *ad libitum*. Since the steers were group-fed, the stilbestrol intake varied according to individual soybean oil meal intake.

The feeding period was 168 days. At zero days, four steers were processed; these steers are referred to as the initial slaughter group. Four steers from each lot were slaughtered at 56, 112, and 168 days. At slaughter time weights of the hide, liver and other items in table 2 were recorded. Empty body weight was calculated by subtracting the weight of the contents of the paunch and intestines from the live shrunk weight.

Following a 24-hour chill, the carcasses were quartered, graded and the rib-eye muscle traced. The right side of the carcass was separated into wholesale cuts using a slight modification of the procedure adopted by the Sixth Annual Reciprocal Meat Conference (1953). Each cut was boned out separately, the edible portion ground and a sample homogenized in a silent cutter. A composite sample representing the entire right side of the carcass was made by combining 10% of the ground meat by weight from each cut.

Samples obtained for chemical analyses were the arm chuck (foreshank included) loin, rib, round (rump and hindshank included), belly cuts (brisket, plate and flank), composite and the 12th rib-eye section from the left side of the carcass. Chemical analyses were made by modified AOAC (1955) procedures.

Efficiency of energy conversion is expressed as the number of Calories consumed per Calorie retained in the dry weight dressed carcass exclusive of that in the bone and kidney knob. Energy in the ration was calculated as 2000 Calories per pound of TDN as recommended by Swift (1957). Calories in the carcass were calculated as 5.65 Calories per gram of protein and 9.30 Calories per gram of fat. Total increase in pounds of carcass protein and fat of each group of steers was determined using the composition of the initial slaughter group as the base.

Since analysis of variance showed no interaction between treatment and year, statistical analysis was run on the combined data from both years. Differences between treatment means were tested for significance by use of Duncan's Multiple Range Test (Duncan, 1955).

Results

Feed Lot Performance. Table 1 shows that steers fed 10 mg. of stilbestrol did not make significantly faster gains than the controls during any of the three stages. Lot III (30 mg.) steers gained 0.32 lb. ($P<0.01$), 0.34 lb.

TABLE 1. EFFECT OF STILBESTROL ON LIVEWEIGHT GAIN, FEED CONSUMPTION AND FEED EFFICIENCY

Stage	Lot	No. steers	Av. initial weight (lb.)	Av. daily gain (lb.)	Lb. TDN/100 lb. gain
	I–0 mg.	24	560.3	3.16	456.4
0–56 days	II–10 mg.	24	567.4	3.04	458.4
	III–30 mg.	24	565.5	3.48**	407.8
	I–0 mg.	16	561.5	2.66	557.2
0–112 days	II–10 mg.	16	568.8	2.74	526.0
	III–30 mg.	16	567.2	3.00*	497.0
	I–0 mg.	8	556.5	2.44	609.0
0–168 days	II–10 mg.	8	575.8	2.54	586.9
	III–30 mg.	8	574.0	2.76	555.3
Period					
0–56 days	Same as stage one above				
	I–0 mg.	16	739.0	2.16*	706.6
56–112 days	II–10 mg.	16	737.0	2.50	597.6
	III–30 mg.	16	760.0	2.58	610.6
	I–0 mg.	8	847.0	2.14	690.2
112–168 days	II–10 mg.	8	866.0	2.44	628.4
	III–30 mg.	8	915.5	2.27	702.5

** Significantly different at P=0.01.
* Significantly different at P=0.05.

(P<0.05) and 0.32 lb. (not statistically significant at P=0.05) more per day than the controls for the 0–56, 0–112 and 0–168 day stages, respectively.

The 10-mg. level of stilbestrol did not appear to affect feed efficiency (lb. TDN/100 lb. gain) at 56 days but increased it by 5.9% at 112 days and 3.8% at 168 days. Increase in feed efficiency over that of the controls for Lot III (30 mg.) was 11.9%, 12.1%, and 9.6%, respectively, for the 0–56, 0–112, and 0–168 day stages. Table 1 also shows that treated steers continued to respond to stilbestrol throughout the experiment. By consecutive 56-day periods, feed efficiency and rate of gain were improved over that of the controls.

Stimulation of appetite for concentrate was evidenced by the increased consumption of the grain mixture by Lot III (30 mg.) steers. However, less hay was consumed by the treated steers. Clegg and Cole (1954) reported increased consumption of both concentrate and hay, while Beeson *et al.* (1956) found little difference in feed consumption.

Slaughter Data. Results of various measurements taken at slaughter appear in table 2. Lot III (30 mg.) steers exhibited heavier (P<.05) empty body weights, significantly less fill, and a greater percentage of liver than Lot I (0 mg.) steers. Lot II (10 mg.) steers had a higher percentage of hide (P<.05) for combined stages. Although not presented, the data

TABLE 2. EFFECT OF STILBESTROL ON SLAUGHTER DATA

Item	Initial slaughter group	0–56 days			0–112 days			0–168 days			Combined stages		
		Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.
No. steers	8	8	8	8	8	8	8	8	8	8	24	24	24
Live wt. (shrunk) lb.	525.1	695.4	703.4	716.2	833.6	846.4	861.8	935.4	965.4	1007.0	821.4	838.4	861.7
Live shrink, %	6.06	5.30	5.20	6.06	4.70	4.68	4.08	3.53	3.90	3.24	4.50	4.59	4.46
Empty body wt., lb.	454.5	620.0	625.9	645.8	762.9	769.6	786.5	857.8	888.8	931.2	746.9	761.4	787.8[c]
Fill, %	14.08	11.04	10.98[b]	9.84[c]	8.51	9.08	8.70	8.32	7.86	7.48	9.29	9.30[b]	8.67[c]
Hide, %	10.59	10.02	10.36	10.41	9.12	9.96[a]	9.63	9.60	9.83	9.78	9.58	10.05[a]	9.94
Liver, %	1.46	1.55	1.52[b]	1.66	1.38	1.44	1.52[c]	1.27	1.30	1.30	1.40	1.42[b]	1.50[c]*
Live grade[o]	3.4	5.1	5.4	5.6	7.5	7.2	7.8	8.2	8.2	8.8	7.0	7.0	7.4
Carcass grade[o]	2.2	6.0	5.8	5.6	7.6	7.5	7.8	8.2	8.2	8.2	7.2	7.2	7.2
Dressing % (cold)	53.22	55.16	55.74	56.38	59.58	58.08[d]	59.46	60.06	60.05	60.99	58.26	57.96[b]	58.94
Cooler shrink, %	4.04	2.26	2.31	2.30	2.08	1.98	1.98	1.80	1.76	1.92	2.05	2.02	2.06

[a] Lot II Significantly different from Lot I at P=0.05.
[b] Lot II Significantly different from Lot III at P=0.05.
[c] Lot III Significantly different from Lot I at P=0.05.
[d] Lot II Significantly different from Lot I and Lot III at P=0.05.
* Both a letter and an asterisk denotes P=0.01.
[o] Top prime=15, Low utility=1.

TABLE 3. EFFECT OF STILBESTROL ON CERTAIN CARCASS CHARACTERISTICS

Item	Initial slaughter group	0–56 days			0–112 days			0–168 days			Combined stages		
		Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.
No. steers	8	8	8	8	8	8	8	8	8	8	24	24	24
Carcass wt., rt. side, lb.	139.75	192.80	196.00	201.12	248.00	245.44	256.12	281.80	290.75	307.75	240.90	244.00	255.00
Forequarter, %	51.94	51.64	52.40	51.77	52.12	51.96	52.50	51.85	51.82	52.14	51.87	52.06	52.04
Chuck, %	28.16	27.48	28.42	28.08	27.74	27.40	28.10	26.92	26.94	27.30	27.38	27.38	27.82
Foreshank, %	5.03	4.04	4.12	4.23	3.76	3.80	3.60	3.74	3.54	3.62	3.84	3.82	3.82
Brisket, %	3.77	3.96	3.55	4.15	4.08	4.04	4.08	4.11	3.95	4.26	4.05	3.84[b]	4.16
Rib, %	8.52	8.68	8.76	8.50	8.82	9.00	9.40	9.02	9.10	8.98	8.84	8.95	8.96
Trim, %	....	....	....	....	5.07	3.48	4.18	6.54	4.32	5.07	....	....	....
Plate, %	5.14	7.18	7.15	7.28	7.50	7.71	7.34	8.05	8.14	7.78	7.58	7.66	7.46
Hindquarter, %	48.02	48.36	47.60	48.23	47.88	48.04	47.80	48.15	48.18	47.86	48.13	47.94	47.96
Loin, %	15.74	15.76	15.58	15.54	15.31	15.90	15.60	15.82	16.12	16.40	15.63	15.86	15.84
Trim, %	.....	.....	.....	.....	6.98	5.54	6.62	8.38	8.86	8.84	....	....	....
Flank, %	3.55	4.68	4.44	4.48	5.30	5.05	5.05	5.78	5.66	5.18	5.26	5.05	4.90[c]
Round, %	28.20	26.02	25.98	26.48	24.94	24.68	24.75	24.04	23.62	23.98	25.00	24.76	25.06
Rump, %	5.10	5.14	5.52	5.51	5.48	5.48	5.66	5.21	5.88[a]	5.94[c*]	5.28	5.63[a*]	5.70[c*]
Hindshank, %	5.71	4.64	4.68	4.68	4.22	4.10	4.01	4.25	4.00	3.98	4.37	4.26	4.22
Kidney knob, %	1.16	2.21	1.84[a]	1.80[c]	2.53	2.61	2.42	2.52	2.60	2.43	2.42	2.34	2.21
Bone, %	21.35	16.97	17.53	16.60	14.53	14.54	14.24	13.13	13.64	13.44	14.88	15.24	14.76
Rib eye area, sq. in.	8.13	7.77	7.97	8.60	9.00	9.24	9.87[c]	9.81	9.80	10.12	8.86	9.00[b]	9.70[c*]
Fat covering over 12th rib, in.	0.16	0.38	0.31	0.29	0.53	0.48	0.50	0.68	0.64	0.66	0.53	0.44	0.48

[a] Lot II Significantly different from Lot I at P=0.05.
[b] Lot II Significantly different from Lot III at P=0.05.
[c] Lot III Significantly different from Lot I at P=0.05.
[*] Both a letter and an asterisk denotes P=0.01.

on percent blood, head, spleen, heart, and kidney showed no difference due to treatment. Percent feet, paunch, lungs and trachea were slightly but not consistently affected by stilbestrol.

Neither level of stilbestrol caused inferior carcasses as judged by carcass grade. The 30-mg. level did not reduce dressing percentage; however, Lot II (10 mg.) steers dressed slightly lower than the controls at 112 days. Andrews *et al.* (1956) and Clegg and Carroll (1957) found no difference in dressing percentage between controls and treated steers receiving 10 mg. stilbestrol.

Carcass Characteristics. In table 3 are presented the weights of wholesale cuts expressed as a percentage of the weight of the right side of the carcass. Except for the flank, rump, brisket, and kidney knob, treatment had no significant affect in changing the proportion of the various cuts in the carcass. The significantly greater percentage of rump obtained at both levels of stilbestrol was offset by a significant ($P<.05$) reduction in percent kidney knob and a tendency toward less flank. A significant increase in percent rump because of stilbestrol treatment was found by Clegg and Carroll (1957) while Cahill *et al.* (1956) reported a lighter flank and kidney knob. Although not significant, thickness of external fat at the 12th rib and trim from the rib and loin was less from treated steers during all stages. Also, stilbestrol did not significantly alter the percentage of total bone in the carcass.

Carcass Composition. Results of protein, fat, and moisture analyses appear in table 4. Results from the composite sample show that carcasses from Lot III (30 mg.) contained a significantly greater percentage of protein and moisture and reduction in percent fat. These carcasses had a protein content approximately 1% higher, a water content 2% higher and a fat content about 3% lower than the controls at 56 days. Lot II (10 mg.) carcasses also had a significantly greater percentage of protein at 56 days.

Similar results were obtained for the individual cuts. Greater and more consistent differences resulted from treatment at the 30-mg. level than at the 10-mg. level of stilbestrol. The differences were greatest at 56 days and tended to disappear by 168 days. Usually the composition of carcasses from Lot II (10 mg.) was intermediate between that for Lots I (0 mg.) and III (30 mg.). From table 4 it can be seen that differences between the 30-mg. lot and the control lot were of such magnitude to show a definite alteration in carcass composition. These differences were not always significant because of variation within treatment and a small number of replicates. Results show that the effect was not limited to specific cuts.

Ether extract of the 12th rib eye is a measure of the amount of marbling and indicates that treated steers had less of this desirable characteristic at 56 days; however, this was overcome by 112 and 168 days.

Table 5 shows that treatment with stilbestrol resulted in more pounds of protein and moisture during all stages. Fewer pounds of fat were produced by treated steers at 56 days. By 112 days there was little difference

TABLE 4. EFFECT OF STILBESTROL ON THE PROTEIN, MOISTURE AND FAT CONTENT OF BEEF CARCASSES

Item	Initial slaughter group	0–56 days			0–112 days			0–168 days			Combined stages		
		Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.	Lot I 0 mg.	Lot II 10 mg.	Lot III 30 mg.
Composite													
Protein, %	19.64	17.98	18.62[a]	18.84[c*]	16.67	16.89	17.34	15.73	15.83	16.00	16.80	17.12	17.39[c*]
Moisture, %	71.08	63.04	64.06	65.45[c]	58.46	58.28	59.13	55.37	54.67	56.09	58.96	59.00	60.22
Fat, %	8.16	17.82	16.41	14.84[c]	24.32	24.48	23.20	28.83	29.50	27.62	23.66	23.46[b]	21.88[c]
Chuck													
Protein, %	19.48	17.79	18.47	18.66	17.04	17.38	17.82[c]	16.24	16.73	16.86	17.02	17.53[a]	17.78[c*]
Moisture, %	71.98	65.48	65.80	67.48	60.92	60.88	62.04	59.17	58.47	59.70	61.86	61.72[b]	63.07[c]
Fat, %	7.36	15.48	14.31	12.93	21.37	20.43	19.72	23.43	24.66	23.08	20.46	19.80	18.58[c]
Rib													
Protein, %	19.68	16.68	16.94	17.48	15.19	15.42	15.34	13.65	13.87	14.48	15.17	15.41	15.76[c]
Moisture, %	71.03	59.36	60.72	62.46[c]	53.06	53.66	53.56	50.17	49.05	50.93	54.20	54.48	55.64
Fat, %	8.09	22.66	21.18	19.25[c]	31.10	30.28	30.80	36.35	36.92	34.25	30.04	29.46	28.10
Loin													
Protein, %	19.56	17.89	18.40	18.84[c]	16.42	16.58	16.55	15.22	15.56	15.96	16.50	16.84	17.12[c]
Moisture, %	70.86	63.04	64.42	65.41[c]	57.25	58.00	58.12	54.82	53.94	55.79	58.36	58.79	59.78
Fat, %	7.68	17.73	15.91	14.36[c]	25.46	24.44	24.30	29.58	29.58	28.05	24.26	23.31	22.24[c]
Belly													
Protein, %	18.60	15.80	16.10	16.66	13.46	13.19	13.74	11.92	12.21	12.71	13.72	13.83[b]	14.37[c]
Moisture, %	66.26	53.82	56.26	57.72[c*]	47.92	47.76	48.70	44.42	43.02	45.85	48.72	49.02[b]	50.76[c]
Fat, %	14.07	29.14	26.89	24.69[c]	38.24	38.54	36.96	43.26	44.53	41.28	36.88	36.65[b]	34.31[c]
Round													
Protein, %	19.44	19.02	19.50	19.70	18.34	18.46	18.68	17.08	17.78[a]	17.84[c]	18.15	18.58[a]	18.74[c*]
Moisture, %	72.11	66.74	67.68	68.96[c]	63.60	63.02	64.28	62.04	61.70	61.96	64.12	64.10	65.06
Fat, %	6.38	12.60	11.14	9.62[c]	16.58	16.54	16.03	20.30	20.08	19.66	16.50	15.92	15.11
12th rib eye													
Protein, %	21.96	22.24	22.62	22.59	21.87	22.43[a]	22.54[c]	21.71	22.26	22.16	21.94	22.44[a]	22.43[c]
Moisture,[d] %	75.22	73.13	73.64	73.83	73.04	72.72	72.39	71.01	70.51	70.90	.....	.....	.....
Fat,[d] %	1.50	3.12	2.22	2.32	3.53	3.40	3.77	5.96	6.38	5.36	.....	.....	.....

[a] Lot II Significantly different from Lot I at P=0.05.
[b] Lot II Significantly different from Lot III at P=0.05.
* Both a letter and an asterisk denotes P=0.01.
[c] Lot III Significantly different from Lot I at P=0.05.
[d] Fat and moisture % for the 0–112 and 0–168 day stages from 1956 data only.

TABLE 5. EFFECT OF STILBESTROL ON THE POUNDS OF CARCASS PROTEIN, FAT, MOISTURE AND DRY MATTER

Stage, lot and stilbestrol	Protein, lb.	Fat, lb.	Moisture, lb.	Dry matter, lb.
0–56 days				
Lot I (0 mg.)	56.0	55.5	196.4	111.5
Lot II (10 mg.)	58.8	51.8	202.4	110.6
Lot III (30 mg.)	61.8	48.7	214.8	110.5
0–112 days				
Lot I (0 mg.)	68.6	100.0	240.5	168.6
Lot II (10 mg.)	68.8	99.5	236.9	168.3
Lot III (30 mg.)	73.8	98.8	251.8	172.6
0–168 days				
Lot I (0 mg.)	74.8	137.0	263.2	211.8
Lot II (10 mg.)	77.1	143.6	266.2	220.7
Lot III (30 mg.)	82.8	143.0	290.4	225.8
Combined stages				
Lot I (0 mg.)	66.4	97.5	233.4	164.0
Lot II (10 mg.)	68.2	98.3	235.4	166.5
Lot III (30 mg.)	72.8	96.8	252.3	169.6

among lots and by 168 days the treated steers had produced more total pounds of fat. Total pounds of dry matter deposited were virtually the same for all lots at 56 days. At 112 and 168 days carcasses from the 30-mg. lot contained 4.0 and 14.0 lb. more dry matter; 11.3 and 27.2 lb. more moisture.

Efficiency of Protein and Energy Conversion. Comparison by combined stages (table 6) shows that treated steers were markedly more efficient than the untreated controls in converting feed protein into carcass protein. This increase in protein conversion is accounted for in the higher percent of carcass protein of treated steers and their greater body weights.

Little difference was found in enregy conversion data between the controls and the 10-mg. stilbestrol lot. At 56 days the steers in Lot III (30 mg.)

TABLE 6. EFFECT OF STILBESTROL ON PROTEIN AND ENERGY CONVERSION DATA [a]

Lot	0–56 days	0–112 days	0–168 days	Combined stages
Pounds of protein consumed per pound of protein retained in dressed carcass				
I–0 mg.	8.04	9.62	11.17	9.61
II–10 mg.	6.24	8.38	9.86	8.16
III–30 mg.	5.46	7.00	8.46	6.97
Calories consumed per calorie retained in protein and fat of dressed carcass				
I–0 mg.	8.16	8.22	8.38	8.25
II–10 mg.	8.32	7.95	8.21	8.16
III–30 mg.	8.96	7.77	8.15	8.29

[a] See procedure section of text for method of calculation.

were less efficient, while later during the feeding period the controls became slightly less efficient. This data could not be treated statistically; however, it appears that stilbestrol did not significantly influence efficiency of energy conversion from feed into the carcass.

Discussion

The lack of response in each of the two year's trials in rate of gain and feed efficiency of steers fed the 10 mg. level of stilbestrol is not readily explainable. This is at variance with results published by other investigators (Beeson *et al.*, 1956; Burroughs *et al.*, 1955; Perry *et al.*, 1955). The improved performance in both trials of steers fed 30 mg. of stilbestrol demonstrates that under conditions of this experiment 10 mg. was definitely not the optimum level for stimulation of growth and feed efficiency.

Chemical analysis of wholesale cuts and a composite sample of the right side of the carcass clearly showed that stilbestrol caused increased protein deposition in the carcass especially during early stages of the feeding period. This was accompained by a reduction in fat and increased moisture content. Beeson *et al.* (1956) reported similar results from analysis of the 12th rib section.

The data on live and carcass measurements and the comparative weights of the cuts of meat indicate that stilbestrol had little effect on carcass conformation. Carcass value was not altered by a greater or lesser percentage of the higher priced cuts such as the rib, loin, or sirloin. However, the over-all carcass merit was influenced by an alteration in the composition of meat from treated versus nontreated steers. Although stilbestrol supplementation increased body weights, this did not result in more efficient production of edible dry matter. Conversion of feed energy into consumable carcass energy on a caloric basis was not increased by stilbestrol feeding and there was less edible dry matter and also less calories, but more protein *per pound of meat* from the treated steers. However, throughout the experiments stilbestrol-treated steers deposited more protein in the carcass per unit of protein consumed. It is not known from this study whether or not the decreased fat content of the carcass from stilbestrol treated steers which accompanied the increased content of protein and water altered significantly the quality of the meat.

The finding that efficiency of conversion of feed energy into carcass energy was not altered in stilbestrol-fed steers is of significance and supports the idea that ration digestibility is not altered by stilbestrol supplementation.

The data suggest that stilbestrol prolonged the growth phase of steers fed a fattening ration. This resulted in increased deposition of carcass protein and moisture and delay in the deposition of fat. Stilbestrol-fed steers were more efficient in the conversion of feed dry matter into body weight during early stages probably by virtue of deposition of lower-calorie protein and water rather than high-calorie fat. During the early stages,

however, their caloric efficiency appeared to be less. In later stages of the experiment treated steers were able to gain weight faster at higher feed efficiency despite the fact that they were depositing as much or more fat. It may be postulated that during this period their greater size and increased feed intake caused a lower maintenance requirement per unit of feed intake and therefore greater efficiency as compared to the controls. However, even at the 168-day slaughter stage, treated steers were still higher in percentage moisture and protein and lower in percent fat.

Results of this experiment and others point out that stilbestrol is concerned directly or indirectly with protein and/or fat metabolism. This is evident from the increased percentage of carcass protein and markedly improved efficiency of protein conversion. Conversely, there was a decrease in percent carcass fat, external trim, and percentage of kidney knob. Whether this is augmented through the growth hormone as suggested by Preston and Gee (1957) and recently by Struempler and Burroughs (1959) or through the pituitary-adrenal axis as discussed by Clegg and Cole (1954) remains to be established.

Summary

The effects of orally administered stilbestrol were studied in two trials involving a total of 80 yearling steers. Three levels of stilbestrol were fed: 0 mg., 10 mg., and 30 mg. per steer per day. Protein, moisture, and fat content of the carcass, certain slaughter and carcass characteristics, and feed lot performance were studied at 0, 56, 112, and 168 days during a 168-day fattening period.

The 10-mg. level of stilbestrol did not significantly stimulate rate of gain above that of the controls, nor was there a marked increase in feed efficiency during any of the three stages. Steers fed at the 30-mg. level of stilbestrol gained 0.32 lb. ($P<0.01$) and 0.34 lb. ($P<0.05$) more than the controls for the 0–56 and 0–112 day stages and 0.32 lb. (not significant) more during the 0–168 day stage. Feed efficiency was increased up to 12% during the 0–112 day stage. Both levels of stilbestrol increased efficiency of protein conversion from feed to carcass. On an energy conversion basis there was little or no difference between efficiency of control and treated steers when stilbestrol was fed for at least 112 days.

Stilbestrol caused an increase in carcass protein and moisture and a decrease in carcass fat as compared to untreated controls. These effects were more pronounced at 56 days than at 112 or 168 days. The most significant alteration in carcass composition was obtained with the 30-mg. level of stilbestrol. Treatment did not significantly affect live or carcass grade, nor percent bone in the carcass. Carcass conformation was only slightly altered, those wholesale cuts affected somewhat by treatment being the rump, foreshank, brisket, and kidney knob.

Results indicate that stilbestrol stimulates the growth phase of steers and causes increased protein deposition early in the feeding period. This

effect becomes less with prolonged supplementation. Thus, the age of the steers and/or the length of time on feed are factors which strongly influence the extent to which stilbestrol treatment will alter carcass composition or quality.

Literature Cited

Andrews, F. N., Martin Stob, T. W. Perry and W. M. Beeson. 1956. The oral administration of diethylstilbestrol, dienestrol and hexestrol for fattening calves. J. Animal Sci. 15:685.

A.O.A.C. 1955. Official Methods of Analysis (8th ed.). Association of Official Agricultural Chemists. Washington, D. C.

Beeson, W. M., F. N. Andrews, Martin Stob and T. W. Perry. 1956. The effects of oral estrogens and androgens singly and in combination on yearling steers. J. Animal Sci. 15:679.

Burroughs, W., C. C. Culbertson, E. Cheng, W. H. Hale and P. Homeyer. 1955. The influence of oral administration of diethylstilbestrol to beef cattle. J. Animal Sci. 14:1015.

Cahill, V. R., L. E. Kunkle, E. W. Klosterman, F. E. Deatherage and E. Wierbicki. 1956. Effect of diethylstilbestrol implantation on carcass composition and the weight of certain endocrine glands of steers and bulls. J. Animal Sci. 15:701.

Clegg, M. T. and F. D. Carroll. 1957. A comparison of the method of administration of stilbestrol on growth and carcass characteristics of beef steers. J. Animal Sci. 16:662.

Clegg, M. T. and H. H. Cole. 1954. The action of stilbestrol on the growth response in ruminants. J. Animal Sci. 13:108.

Deans, R. J., W. J. Van Arsdell, E. P. Reineke and L. J. Bratzler. 1956. The effect of progesterone—estradiol implants and stilbestrol feeding on feed lot performance and carcass characteristics of steers. J. Animal Sci. 15:1020.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11:1.

Kastelic, J., P. Homeyer and E. A. Kline. 1956. The influence of the oral administration of diethylstilbestrol on certain carcass characteristics of beef cattle. J. Animal Sci. 15:689.

Perry, T. W., W. M. Beeson, F. N. Andrews and Martin Stob. 1955. The effect of oral administration of hormones on growth rate and deposition in the carcass of fattening steers. J. Animal Sci. 14:329.

Preston, T. R. and Isoline Gee. 1957. Effect of hexestrol on carcass composition and efficiency of food utilization in fattening lambs. Nature 179:247.

Proceedings of the Sixth Annual Reciprocal Meat Conference. 1953. National Livestock and Meat Board. Chicago 5, Illinois.

Swift, R. W. 1957. The caloric value of T.D.N. J. Animal Sci. 16:753.

Struempler, A. W. and Wise Burroughs. 1959. Stilbestrol feeding and growth hormone stimulation in immature ruminants. J. Animal Sci. 18:427.

EFFECTS OF PIG GROWTH HORMONE ON PIGS[1]

B. HENRICSON[2] AND S. ULLBERG[3]

Royal Veterinary College, Stockholm, Sweden

THE hypophyseal growth hormone (GH) is a primary regulator of muscle and skeleton growth. Its effects are evident not only quantitatively but also qualitatively such as in governing the relationship between the metabolism of muscle protein and fat. Pigs are an obvious species on which to examine more closely the effects of this hormone because both rapid growth and the formation of muscle protein and fat are questions of prime practical importance.

A highly purified GH prepared from pig hypophyses was injected daily into pigs. Growth, feed consumption, and certain blood values were followed with the results to be described in this paper.

There are a few earlier reports dealing with the same subject. Giles (1942) administered an undefined extract of the anterior pituitary to ten pigs. Increased growth of some bones was the only effect described by him.

The most extensive studies on pigs up to the present have been carried out by Turman and Andrews (1955). Eleven pigs, all castrated, were given GH prepared in the manner described by Wilhelmi *et al.* (1948). Although treated animals did not gain significantly more weight than control animals, they consumed less feed per day and required less feed per unit gain. The bodies of the treated animals contained relatively more protein and water than those of the controls. Higher blood sugar levels were found in the treated animals than in the controls. When slaughtered, the treated pigs showed signs of fatty infiltration and degeneration of the liver and fatty and albuminous degeneration of the kidneys. Four of the original eleven pigs in the treated group died during the experiment without any cause being given.

Experimental Procedure

The pigs, which belonged to a litter of twelve born February 1, 1959, were divided into two groups of three males and two females each. The parents were Swedish lantras and not related to each other. The experiment was commenced when the pigs were 24 days old. Each day except Sundays, the pigs in the treated group received an injection of GH in the extensor muscles of the neck.

Pituitaries were collected after slaughter from pigs weighing 70 to 90 kg. They were immediately frozen and lyophilized. GH was purified ac-

[1] Financial support for this investigation has been received from "Fonden för främjande av forsknings- och försöksverksamheten på jordbrukets område".

[2] Department of Animal Nutrition, Genetics and Hygiene.

[3] Department of Pharmacology.

cording to the chromatographic method of Li and Papkoff (1956). The biological potency of the GH preparation was determined by the tibia test in hypophysectomized rats (Greenspan *et al.*, 1949). Ten mcg. of GH gave a tibia width of 210±5 micra and 40 mcg., a width of 259±3 micra. The average width of the tibial epiphysis of the control rats was 174±3 micra. From each pituitary about 2.5 mg. of GH was obtained.[4] Doses are listed in table 1. Phosphate buffer with a pH of about 7.4 was used as diluent.

During the first experimental period and the first part of the second period the control pigs received injections of a corresponding volume of physiological saline solution. The pigs in both groups nursed the sow during

TABLE 1. DOSAGE OF GH INJECTED

Experimental period	Age of pigs, days	GH, mg./kg. body weight	Concentration of GH in buffer, %
I	24–45	0.1	0.1
	46–52	0.2	0.1
II	53–78	0.05	0.05
	79–93	....	....
	94–132	0.05	0.025

the first period. Since the sow did not give sufficient milk, the pigs were allowed a protein concentrate and whole milk *ad lib.*

For the second experimental period the pigs were divided into two groups and placed in two adjacent and, as nearly as possible, identical boxes. Each box measured 2.5 x 2.7 m. and was fitted with an automatic feeder and a water trough of identical design and placed in corresponding positions. The pigs were allowed both water and feed *ad libitum.*

The following ration was fed: 44.2% ground oats, 44.2% ground barley, 6.2% meat meal, 2.7% fish meal, 0.9% chalk (approx. 366 gm. Ca/kg.), 0.9% bone meal (approx. 275 gm. Ca and 131 gm. P/kg.), and 0.9% Ewomin KK.[5] The feed mixture contained 880 gm. dry matter, 0.83 Scandinavian feed units, 111.2 gm. digestible protein, 12.4 gm. Ca, and 9.6 gm. P per kg.

Weighing took place once weekly at a fixed time (Mondays, 10–11 a.m.) throughout the entire experiment. During the first period weights were read to an accuracy of 0.01 kg. and during the second, to 0.1 kg. In conjunction with weighing, blood samples were taken from the anterior vena cava (Carle and Dewhirst, 1942) for the determination of glucose and phosphorus levels. Towards the end of the experiment, however, blood

[4] We are indebted to Dr. C. A. Gemzell, Karolinska Hospital, Stockholm for the preparation of the pig GH used in this study.

[5] Ewomin KK (Ewos) contains per gm. 24 I.U. vitamin B_1, 10 gamma vitamin B_2, 100 gamma nicotinic acid, 200 I.U. vitamin D_2 and in addition, pantothenic acid, biotin, choline, trace elements and CaO, 36.2% (Ca 25.9%).

samples were not taken on every occasion since pigs fight violently against this procedure and the earlier values did not reveal any definite trends.

Our estimation of possible differences in the relationship between fat and protein in the musculature and connective tissue of treated and untreated pigs can be gained from the specific weights. A significant increase in the ration between protein and fat ought to be reflected in a corresponding increase in the specific weight. Immediately after the pigs were slaughtered and eviscerated, the bodies were weighed and their volume established by immersion in water.

Results

General Status. At 45 days of age (period 1) all pigs in both groups had slight diarrhea. The supplement was removed and the diarrhea subsided after a few days. No recurrence was observed when the supplement was fed again. From the 40th day, one of the males in the treated group was depressed, had little appetite and became stunted. The temperature remained normal but leukocytosis and a low haemoglobin content could be demonstrated in the blood sample taken on the 45th day. At this point growth of the pig was markedly retarded. By the 50th day, however, the pig was much improved. When weighed on the 60th day, it was apparent that the pig had attained much the same rate of growth as the other animals in the group.

Slight coughing was noted on occasion among all the pigs during the second experimental period. It was especially evident when the pigs were disturbed for the injections. No other noteworthy clinical signs were observed during the experiment. The males were castrated at 35 days of age.

Feed Consumption. It was impossible to record feed intake during the first experimental period while the pigs nursed their dam. During the second period, the amount of feed consumed per week by each group was measured. The average is given in fig. 1 as the number of feed units (f.u.) consumed per kg. growth. The mean for the control groups is numerically greater than that for the treated pigs but the difference is not significant.

Growth. Mean growth in grams per day is given in fig. 2. The mean for the control groups represents all animals in the group while separate means

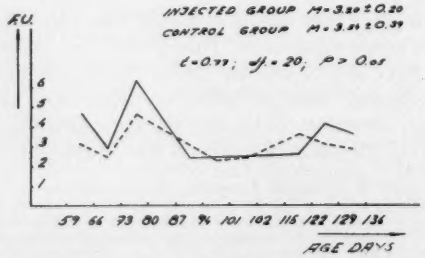

Figure 1. Consumed feed units/kg. gain.

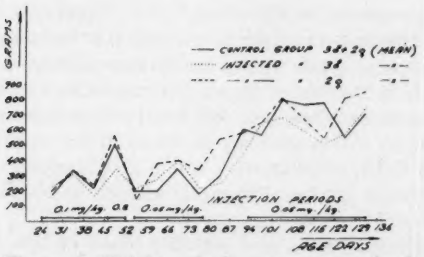

Figure 2. Weight gain in grams per animal and day.

are given for the sexes in the treated group. Our results motivated making this distinction. In a study of the weight gains of young pigs at various ages, Olofsson (1949) demonstrated that there was no difference in growth rate between females and castrated males. His results were based upon a large number of animals (at birth 1,497 Swedish lantras pigs) and covered the period from birth up to about 180 days of age. As was the case in our experiment, his pigs were weighed once weekly. Variance analysis of our results gave no significant difference in growth within weeks between the sexes in the control group. In the treated group, however, there was a significant difference ($P \cong 0.05$) in growth within weeks between sexes. Although this significance is slight, it ought to be taken into account in our limited material. For this reason we have chosen to give separate means in fig. 2 for the females and males in the treated group. We obtained the following results for mean growth in grams per animal and day: Control group, 440; treated group, males 400; and, treated group, females, 490. Variance analysis of the values for each weekly weighing gave the results shown in table 2.

TABLE 2. ANALYSIS OF VARIANCE BETWEEN CONTROL GROUP AND TREATED GROUPS, MALES AND FEMALES

	Males			Females		
Item	Degrees of freedom	Sum of squares	Mean square	Degrees of freedom	Sum of squares	Mean square
Between weeks	15	262.12	17.47	15	255.29	17.02
Within weeks	112	102.69	0.92	96	68.35	0.71
Between control group and treated group	16	18.01	1.13	16	20.76	1.30
Within control group and treated group	96	84.68	0.88	80	47.59	0.59
Total	127	364.81		111	323.64	
Quotient		$\frac{1.13}{0.88}=1.28$	$P>0.05$		$\frac{1.30}{0.59}=2.30$	$P \cong 0.01$

Blood Glucose. As is evident from fig. 3, blood glucose levels were highest during the first experimental period and variations between the different samples were great. No sex differences could be demonstrated for either the control or the treated group. The means for all 12 samples were, for the control animals, 90 mg. %, and for the treated animals, 88 mg. %.

Variance analysis within sampling occasions of the results obtained does not suggest any difference. Variation within groups appears to be as great as variation between groups. The mean squares were 279 and 229 with 93 and 12 degrees of freedom, respectively.

Blood Phosphorus. Fig. 3 also includes blood phosphorus levels with means for the control group and the treated group being given for each

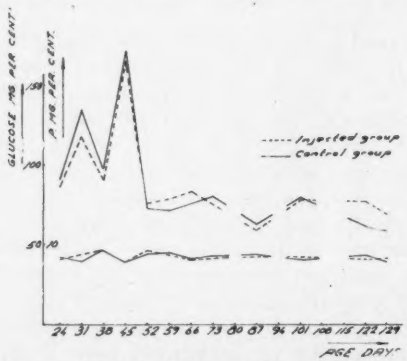

Figure 3. Blood glucose and blood inorganic phosphorus.

sample. No sex difference in either group could be demonstrated. Means for the whole experiment were 8.3 mg. % for the control animals and 8.4 mg. % for the treated group.

Variance analysis gave significant differences between sampling occasions but could not demonstrate a difference between control and treated animals within sampling occasions.

Post-mortem Examination. The pigs were killed at 140 days of age and examined in the usual manner. The only macroscopical lesions noted were signs of enzootic pig pneumonia in the male in the treated group which had shown clinical signs between the 40th and the 50th days. Tissues for histological examination were taken from the endocrine glands, liver, and pancreas.

There were no systematic differences between the relative weights of the liver and the endocrine glands for the treated and untreated animals. Histologically, as well, no differences were discernible.

The specific weights found for the control groups were: males, 1.025 ± 0.009; females 1.030 ± 0.008; and, the mean for the whole group, $1.027 \pm$

0.005. The corresponding values for the treated groups were: males, 1.024 ± 0.004; and females, 1.018 ± 0.012, with a mean of 1.021 ± 0.005. There is no statistical difference between the groups. No significant differences in the protein and fat contents of the musculature and connective tissue are evident although it must be admitted that the experimental groups were small.

Discussion

The major question in an experiment of this nature is whether or not parenteral administration of GH can stimulate increased growth. There is a basic difference in the design of our experiment and the only known comparable one (Turman and Andrews, 1955) since we began the injections at 24 days of age and continued them until the pigs were 132 days old. Turman and Andrews, on the other hand, began their course of injections at a weight of 50 kg., i.e., about the time we concluded our experiment. The magnitude of the daily gain in Turman and Andrews' experiment was naturally greater, 2.26 lb. for the treated animals and 2.19 for the controls, but there was no significant difference between their groups. They pointed out, however, that feed consumption was significantly lower for the treated pigs than for the controls. In our experiment, the treated females had a greater growth rate than the controls while the castrated males had much the same growth rate. Here was a basic difference in the reaction of the sexes to somatotropin. There was no significant difference in feed consumption between the groups although mean weekly consumption was numerically lower for the treated pigs. Unfortunately, we had no possibility of measuring feed consumption separately for the males and females. At the beginning of the second experimental period, there was no distinct difference between the sexes which suggested the desirability of separating them. When considering feed consumption, growth of the treated group must be evaluated against feed consumption by the group since one cannot assume that consumption was as great for the females as for the males. It has become clear that in experiments of this nature the effect of the hormone should be studied on non-castrated males and feed consumption should be measured separately for the sexes.

Baker *et al.* (1956) were able to demonstrate that the total growth hormone capacity of pigs per kg. body weight was relatively great up to 150 days of age. By 225 days an obvious decrease was noticed. The experiment described in this paper largely covers the period when the growth hormone capacity is greatest. Since no definite effects were obtained, especially qualitatively, it is possible that during this period the animals were incapable of responding to an additional hormone stimulation over that given by the autogenous growth hormone.

An observation of general validity for several mammalian species is the diabetogenic effect of GH when given parenterally. In the experiment of

Turman and Andrews (1955) there was a significant increase in blood glucose levels in treated pigs. We were unable to demonstrate a similar increase. The blood phosphorus content in our pigs did not seem to be affected by the administration of GH. Neither were pathological or histological changes observed as a result of the hormone treatment. This affords further evidence for lack of qualitative effects of hormone administration during the period when the normal growth hormone capacity is greatest. It has also occurred to us that in those instances in which pathological side-effects have occurred, a hormone extract of a lower degree of purity may have been employed.

Summary

Between 24 and 132 days of age, pigs were given daily doses of GH prepared from pig pituitaries by the method of Li and Papkoff (1956). The doses were 0.1, 0.2, and 0.05 mg./kg. body weight. Effects of this treatment upon growth, feed consumption, and certain blood values have been followed. Both female pigs and castrated males were given GH. The females had a significantly greater increase in weight. No differences in feed consumption between the groups could be detected; this may depend upon consumption not being measured separately for the females and males. The administration of GH had no apparent effect upon the blood glucose or blood phosphorus levels.

Literature Cited

Baker, B., Jr., R. Hollandbeck, H. W. Norton and A. V. Nalbandov. 1956. Growth hormone content of swine pituitaries in relation to growth rate and age. J. Animal Sci. 15:407.

Carle, B. N. and Wm. H. Dewhirst, Jr. 1942. A method for bleeding swine. J. Am. Vet. Med. Assn. 101:495.

Giles, D. D. 1942. An experiment to determine the effect of growth hormone of the anterior lobe of the pituitary gland on swine. Am. J. Vet. Res. 3:77.

Greenspan, F. S., C. H. Li, M. E. Simpson and H. N. Evans. 1949. Bioassay of hypophyseal growth hormone: the tibia test. J. Endocr. 45:455.

Li, C. H. and H. Papkoff. 1956. Preparation and properties of growth hormone from human and monkey pituitary glands. Science 124:1293.

Olofsson, N. E. 1949. Sambandet mellan ungsvinens ålder och viktökning (with summary in English). Svenska Svinavelsfören. Tidskr. 10:145 and 12:177.

Turman, E. J. and F. N. Andrews. 1955. Some effects of purified anterior pituitary growth hormone on swine. J. Animal Sci. 14:7.

Wilhelmi, A. F., J. B. Fishman and J. A. Russel. 1948. A new preparation of crystalline anterior pituitary growth hormone. J. Biol. Chem. 176:735.

EFFECTS OF LEVEL OF 3, 3′ DIALLYLHEXESTROL ON STEER PERFORMANCE AND CARCASS CHARACTERISTICS[1]

I. A. DYER, E. H. RUPNOW AND W. E. HAM

Washington State University, Pullman

CERTAIN natural and synthetic estrogens are used extensively to increase rates of gain in fattening cattle. A diphenyl hexane derivative, 3, 3′ diallylhexestrol, that has approximately 0.2–2%[2] the estrogenic activity of stilbestrol, also increases rates of gain of fattening cattle (Dyer, unpublished). Because of its low estrogen activity, no related undesirable side effects would be expected.

Experimental

Forty-four yearling grade Hereford steers were weighed and allotted at random into three groups. Group 1 received the control ration while groups 2 and 3 received the same ration containing 1.25 and 2.50 mg. DAH per pound of feed, respectively. These cattle were full-fed individually a ration containing 75% concentrate and 25% chopped alfalfa hay (table 1) for 106 days. Water was supplied by automatic waterers and wood shavings were used as bedding. Steers were weighed individually at approximately 28-day intervals. Rumen microbial activity was determined by the method of Hungate *et al.* (1955) as a possible measure of the influence of treatment on rate of microbial degradation of the ingested feed.

TABLE 1. EFFECTS OF DAH ON PERFORMANCE AND CERTAIN MEASUREMENTS IN STEERS (106-DAY FEEDING PERIOD)

Treatment	1 Control[a]	2 19 mg. DAH/ steer daily	3 38 mg. DAH/ steer daily
No. steers	16	12	16
Av. initial wt., lb.	745	777	805
Av. daily gain, lb.[b]	1.46	1.81	1.71
Av. feed per lb. gain, lb.	9.81	8.74	8.88
Av. shrink to mkt., 78 miles, %	1.75	1.54	1.69
Av. rumen microbiol activity, mm. Hg/min.	1.56	1.61	1.45
Av. serum transaminase (SGO–T units)	121.9	112.5	90.1
Av. dry liver transaminase (SGO–T units)	4300	....	4395

[a] Percentage composition of ration: barley 45.0, beet pulp 16.5, oats 7.5, cottonseed meal 1.5, molasses 3.8, salt 0.7 and alfalfa 25.0. The concentrate portion was pelleted into ½" cubes.

[b] Gain in each lot was reduced because of rumenitis.

[1] Scientific Paper No. 1894. Washington Agricultural Experiment Stations, Project 1217. This study was supported in part by Armour and Company, Chicago. Appreciation is expressed to S. T. Larkin for care of the experimental animals.

[2] Personal communication from Irby Bunding, Armour and Company, Chicago.

Serum and hepatic glutamic-oxalacetic transaminases (SGO–T) were determined on 18 steers (6 from each group) according to the method of Cabaud *et al.* (1956). Blood was drawn on the 44th and 106th day and liver samples obtained at slaughter for transaminase determinations.

Shrink in transit and various slaughter data were obtained from 9 randomly selected steers from each treatment. The carcasses were chilled for 24 hours and the cold carcasses weighed. They were then graded and the loin muscle (Longissimus dorsi) marbling score determined (table 2) by a U.S.D.A. grader. The loin eye area and fat thickness were traced at

TABLE 2. CARCASS DATA

Treatment	1 Control	2 19 mg. DAH	3 38 mg. DAH
No. of animals	9	9	9
Av. cold carcass wt., lb.	523	577	584
Shrink, %	1.97	1.86	1.76
Liver, % of carcass	1.95	1.95	2.02
U.S.D.A. carcass grade[a]	17	18	17.8
Marbling score[b]	4.4	5.4	5.2
Loin eye area, sq. in.	12.25	11.90[c]	12.75
Fat thickness (12th rib), in.	0.48	0.65	0.54
Specific gravity[d]	1.0865*	1.0681	1.0703
Fat, %[d]	26.18*	33.34	32.50

[a] 19, low choice; 18, top good; and, 17, average good.
[b] 7, moderate marbling; 6, modest; 5, small amount; and 4, slight amount.
[c] Significantly different ($P<.05$) from averages of other two lots.
[d] Av. of 6 animals.
* Significantly different ($P<.01$) from averages of other two lots.

the 12th rib. A compensating planimeter was used to determine the area of the loin.

Six steers from each of the three groups were selected at random for specific gravity determinations on the 9, 10 and 11th rib section. The percent fat was determined by the formula of Lofgreen and Garrett (1954) from the specific gravity of the 9, 10 and 11th rib section.

The growth and carcass data were treated by analysis of variance.

Results and Discussion

The inclusion of DAH at the rate of 19 mg. per steer per day increased average daily gain 0.35 lb. ($P<.05$). Twice this level (38 mg.) increased daily gains 0.25 lb., suggesting that the optimum daily intake of DAH for fattening steers is below 38 mg. per day (table 1). Differences ($P>.05$) in gain and feed efficiency between the control and the group fed 38 mg. were not significant. Gains of steers in all groups were suboptimal because of rumenitis. This condition could not be diagnosed until slaughter.

Efficiency of feed utilization was increased 11 and 9% by 19 and 38 mg.

DAH, respectively. These increases were not statistically significant ($P>.05$.)

Differences in total microbial activity of rumen samples from steers on the various treatments were not statistically significant.

It has been shown that the SGO–T level increases with tissue destruction (Blincoe and Dye, 1957; Bowman, 1958). Since gains were suboptimal, serum and hepatic transaminase activity was measured to determine if an internal tissue degeneration were present. Serum transaminase was higher than normal, which indicated a tissue degeneration, but decreased as the level of DAH intake increased. Hence, it might be inferred that DAH reduced the severity of the degeneration (rumenitis). This is equivocal since no quantitative measurement of rumenitis was made at slaughter. Hepatic transaminase was not affected by treatment. DAH does not affect the SGO–T levels in normal steers.[3, 4]

The average dressing percentage, $\frac{\text{cold carcass weight}}{\text{shrunk weight}}$, and carcass weights were 58.1 and 523 lb. for the control group, 59.5 and 577 lb. for the group fed 19 mg. DAH and 58.9 and 584 lb. for the group fed 38 mg. DAH. There was no significant difference among groups in the 24-hour cooler shrink or the weight of liver per unit of body weight.

The carcass grades from group 2 averaged 18 (high good) while carcasses from group 3 averaged 17.8 and those from group 1 graded the lowest, averaging 17 (average good). There was no significant difference among groups. The average marbling scores for groups 1, 2 and 3 were 4.4, 5.4 and 5.2, respectively. As would be expected, the marbling score was related to carcass grade. The above data indicate an increase in fat of the animals fed DAH; however, the increase was not significant ($P>.05$). Group 2 had an average fat covering of 0.65 inch over the 12th rib; group 3 averaged 0.54 inch; and, group 1 had the least, averaging 0.48 inch. The differences were not statistically significant.

Specific gravity of the 9, 10, 11th rib cut was determined to obtain a measurement of carcass fat. Group 1 had a significantly ($P<.01$) higher specific gravity than groups 2 and 3, specific gravities being 1.0865, 1.0681 and 1.0703, respectively. The percent fat of the 9, 10, 11th rib cut was determined by using the formula of Lofgreen and Garrett (1954), $F=\frac{1.155-Gw}{0.0261}$. Since the percentage fat is inversely proportional to the specific gravity, it will be observed that group 1 had the lowest calculated carcass fat.

Summary and Conclusions

Three groups of yearling steers were full-fed individually rations supplying either 0, 19 or 38 mg. DAH per head daily for 106 days. The 19-mg. level increased rates of gain ($P<.05$). The gain of cattle fed 36 mg. per

[3] Personal communication from John Hopper, Armour and Co., Chicago.
Subsequent work at Washington State University.

head daily was not significantly different from that of those fed the control ration.

Shrink, rumen microbial activity, and serum and liver transaminase levels were determined. Differences were not significant. The feeding of either 19 or 38 mg. of DAH increased estimated marbling and the total calculated carcass fat.

Literature Cited

Blincoe, Clifton and W. B. Dye. 1957. Serum transaminase in white muscle disease. Proc. Am. Soc. An. Prod.—Western Section, 8:XXXV.

Bowman, Ollie M. 1958. A study of the influence of certain dietary constituents on the occurrence of histochemical changes in muscular dystrophy. Doctorate Thesis, Washington State University.

Cabaud, P., R. Lepper and F. Wroblemski. 1956. Colorimetric measurement of serum gultamic-oxalacetic transaminase. Am. J. Clin. Path. 26:1101. Tech. Bul. Registry. Med. Technologists 26:203.

Hungate, R. E., D. W. Fletcher, R. W. Dougherty and B. F. Barrentine. 1955. Microbial activity in the bovine rumen; Its measurement and relation to bloat. Applied Microbiology 3:161.

Lofgreen, G. P. and W. N. Garrett. 1954. Creatinine excretion and specific gravity as related to the composition of the 9, 10, 11th rib cut of Hereford steers. J. Animal Sci. 13:496.

ESTIMATION OF CARCASS MERIT OF SWINE FROM LIVE ANIMAL MEASUREMENTS [1]

O. W. Robison,[2] J. H. Cooksey,[3] A. B. Chapman and H. L. Self [4, 5]

University of Wisconsin, Madison

THE preference of consumers for leaner cuts of meat has caused more emphasis to be placed on the carcass merit of hogs. Carcasses of hogs shipped to market can be evaluated, but simple, accurate and objective measurements are needed for dependable predictions of carcass merit from the live animal.

This current demand for leanness emphasizes the importance of the four lean cuts of the pig carcass. Obtaining the weight of these cuts is both slow and expensive. Measurements taken on the uncut carcass or the live animal and which accurately predict the percent lean cuts are desired. Prediction of carcass merit at an early age would be helpful from a marketing standpoint and might enable earlier selection of breeding stock. The labor involved in taking a large number of measurements on the live animal would be prohibitive under commercial conditions. Therefore, the minimum number of measurements which would predict accurately the percent lean cuts is needed.

The purposes of this study were to evaluate the effect of splitting and cutting errors on the accuracy of hog carcass data; to investigate the usefulness of various live hog body measurements taken from 84 to 154 days of age in predicting carcass merit at 210 pounds; and to assess the accuracy of body measurements taken at slaughter weight in predicting carcass merit.

Materials and Methods

Splitting and Cutting Errors. A total of 583 carcasses dressed packer style and weighing 126 to 167 lb. was used. The standard primal cuts of each carcass were cut by hand as outlined in the Fifth Reciprocal Meats Conference Proceedings (1952). Further information concerning these animals is given by Self *et al.* (1957).

Prediction of Carcass Merit from Live Animal Measurements. The data for this study were from pigs in the Wisconsin experimental swine breeding

[1] Paper from the Department of Genetics No. 784 and the Department of Animal Husbandry, Univ. of Wisconsin in cooperation with the Regional Swine Breeding Laboratory, AHRD, ARS, U. S. Department of Agriculture. Published with the Approval of the Director of the Agricultural Experiment Station.

[2] Present address: Department of Animal Industry, North Carolina State College, Raleigh, North Carolina.

[3] Present address: Loomis, Washington.

[4] Present address: Department of Animal Husbandry, Iowa State University, Ames, Iowa.

[5] The authors wish to acknowledge the cooperation of Oscar Mayer and Company, Madison, Wis., in obtaining carcass data and Janet Coyle and Paul V. Hurt for aid in collecting some of the data.

herd mantained in cooperation with the Regional Swine Breeding Laboratory. This herd is being used in an experiment to compare selection based on intrabreed performance with selection based on crossbreed combining ability—recurrent-reciprocal selection.

Purebred Yorkshires, Durocs and Polands, 2-breed crosses of these three breeds and crosses of 2-breed gilts with either spotted Poland China boars inbred Chester White-Landrace boars were used. Purebred and 3-breed crosses (Spotted Poland China boars) were used in 1955, purebred and 2-breed crosses in 1956 and 3-breed crosses (inbred Chester White-Landrace boars) in 1957. A small amount of inbreeding occurred in each of the straightbred groups because of limited numbers of animals per group. All analyses were made within breeding and sex groups.

In 1955 the live animal measurements were taken with the pig in what was considered a normal standing position, head down. In 1956 the correlations between measurements taken this way and those taken with the standing pig snubbed by the upper jaw (head up) were investigated. The high correlations between the measurements taken by the two methods allowed use of the easier, snubbing method, in 1956 and 1957.

The live animal measurements taken were: (1) weight, not fasted, (2) depth of chest from the sternum to the top of the shoulders, (3) width immediately behind the shoulders and at the widest dimension vertically, (4) length of foreleg from the olecranon process to the cleft of the dewclaw, (5) backfat at the shoulder, dorsal to the olecranon process and 1½ inches from the midline, (6) backfat at the loin, dorsal to the posterior pont of curvature of the last rib and 1½ inches from the midline, (7) belly arc, from the junction of the last rib with the vertebral column on one side under the belly to the junction on the other side, (8) circumference of shin, one-half way between the dewclaw and knee, (9) circumference of foreleg, just below the olecranon process, (10) width of the loin at the widest dimension vertically and one-half way between the last rib and the hip bone, (11) width of hams at the widest part of the lower one-half of the ham.

Measurements (1), (2), (3), (4), (5) and (6) were taken in 1955 at 154 days of age and (1), (3), (4), (5), (6), (7), (8), (9) and (10) were taken at 154 days of age in 1956 and at 84, 112, 140 and 154 days of age in 1957. In 1955, measurements (1), (2), (3), (4), (5), (6), (10) and (11) were taken at slaughter weight while, in 1956, (1), (3), (4), (5), (6), (7), (8), (9) and (10) were taken. The animals were weighed weekly as they neared market weight and were taken off feed when they weighed 205 to 225 lb. They were held without feed for approximately 18 hours before slaughter. Carcass data were obtained on 282, 214 and 167 animals in 1955, 1956 and 1957, respectively.

Carcasses were dressed packer style with head and leaf-fat removed. Approximately 24 hours after being placed in the cooler, the carcasses were measured and cut. Carcass data used in this study were: length of

carcass (anterior edge of the first rib at its junction with the vertebrae to the anterior edge of the aitch bone), average carcass backfat (average of measurements taken at the level of the first and last ribs and last lumbar vertebrae), percent lean cuts (twice the weight of lean cuts from the left side divided by the total chilled carcass weight) and loin eye area (longissimus dorsi area at the tenth rib).

Results

Splitting and Cutting Errors. Lasley and Kline (1957) indicated that biased cutout values are obtained when lean cuts consistently are expressed as a percent of either the right or the left side of a carcass. In the present data, the right side was heavier and yielded more primal cuts than the left side (73.5 vs. 72.2 and 47.7 vs. 47.4, respectively) but there was no significant difference in the yield of lean cuts from the two sides (35.48 vs. 35.45). This suggests that the differences in weights between sides were due mostly to errors in cutting that occurred in the fatty portion of the carcass. If the lean cuts from one side were expressed as a percentage of that side, there was a difference between yield of the two sides. However, if the lean cuts from each side were expressed as a percentage of the total carcass weight there was essentially no difference (24.34% vs. 24.33%).

Correlating the weight of the lean cuts from each side with the total weight of the lean cuts for the entire carcass resulted in the same value for each side, $r=0.97$. The correlations of lean cuts from each side (expressed as a percentage of that side) with total percent lean cuts were similar to the correlations of lean cuts from a side (expressed as a percentage of total carcass weight) with total percent lean cuts. This indicates that the ranking of the carcasses will be essentially the same by any of these methods. However, using twice the actual weight of the lean cuts from one side or using twice the weight of the lean cuts from one side expressed as a percent of the total carcass weight will give a more accurate estimate of absolute yield than will any of the other methods. These two methods provide essentially the same information as would be obtained by cutting both sides.

Prediction of Carcass Merit from Live Animal Measurements Taken at 84–154 Days of Age. The correlations of the unshrunk live weight (range 205–225 lb.) or of the shrunk live weight (range 187–220 lb.) with each of the carcass traits studied were low and insignficant. Similarly, the correlations of age at slaughter (range 165–313 days) with each of the carcass traits were low and insignificant. Therefore, it was assumed that variations of this magnitude in weight and age were not important factors in affecting carcass traits and they were disregarded in the analysis.

Means and standard deviations of live animal measurements taken at 154 days of age and carcass traits for 1955 and 1956 are given in table 1. Multiple regression analyses of the 1955 data indicated that 29, 33, 27 and

TABLE 1. MEANS AND STANDARD DEVIATIONS OF LIVE ANIMAL MEASUREMENTS TAKEN AT 154 DAYS OF AGE AND CARCASS TRAITS (POOLED WITHIN BREED AND SEX)

Characteristic	1955		1956	
	Mean	Standard deviation	Mean	Standard deviation
Percent lean cuts	48.4	2.3	47.7	2.4
Loin eye area, sq. in.	3.4	.4	3.3	.4
Length of carcass, in.	28.4	.7	28.7	.8
Av. carcass backfat, in.	1.9	.2	1.8	.2
Weight, lb. (X_1)	124.6	27.5	118.4	26.2
Depth of chest, cm. (X_2)	31.9	3.1	....	...
Width behind the shoulders, cm. (X_3)	25.9	2.7	23.1	2.3
Length of foreleg, cm. (X_4)	23.1	1.6	23.1	1.3
Backfat at shoulder, in. (X_5)	1.2	.3	1.4	.4
Backfat at loin, in. (X_6)	.9	.2	1.0	.3
Belly arc, cm. (X_7)	...	...	64.1	5.1
Circumference of shin, cm. (X_8)	...	...	12.7	.9
Circumference of foreleg, cm. (X_9)	...	...	24.1	2.1
Width at loin, cm. (X_{10})	...	...	17.4	2.2

16% of the variance in percent lean cuts, average carcass backfat, length of carcass and loin eye area, respectively, could be accounted for by the variance in the six independent variables combined.

Predictions of percent lean cuts from live animal measurements taken at 154 days of age are summarized for the 1955 data in table 2. The combination of weight (X_1) and backfat at the loin (X_6) appeared to be the best combination of two measurements for predicting percent lean cuts ($R=.44$). The other pairs of traits gave a smaller multiple correlation and hence are not given in table 2. Similarly, only the combinations of three and four variables with the highest predictive values are presented. The

TABLE 2. MULTIPLE CORRELATION AND PARTIAL REGRESSION COEFFICIENTS FOR PREDICTING PERCENT LEAN CUTS USING VARIOUS COMBINATIONS OF LIVE ANIMAL MEASUREMENTS TAKEN AT 154 DAYS OF AGE (1955)

Independent variables	R	Partial regression coefficients of percent lean cuts (Y) on:[a]					
		X_1	X_2	X_3	X_4	X_5	X_6
X_1, X_2, X_3, X_4, X_5, X_6	0.54	0.08	—.42	—.29	0.64	—2.10	—2.94
X_1, X_2, X_3, X_5	.48	.08	—.35	...	....	—2.16	—4.08
X_1, X_3, X_5, X_6	.47	.08	...	—.34	....	—2.05	—4.08
X_1, X_4, X_5, X_6	.47	.03	...	...	0.41	—2.39	—4.06
X_1, X_2, X_6	.47	.08	—.36	...	....	....	—6.33
X_1, X_3, X_6	.46	.08	...	—.36	....	....	—6.20
X_1, X_4, X_6	.46	.03	...	...	0.40	....	—6.57
X_1, X_5, X_6	.45	.05	...	...	....	—2.28	—4.50
X_1, X_6	.44	.05	...	...	....	....	—6.89

[a] Weight (X_1), depth of chest (X_2), width behind the shoulders (X_3), length of foreleg (X_4), backfat at shoulder (X_5) and backfat at loin (X_6).

TABLE 3. MULTIPLE CORRELATIONS AND PARTIAL REGRESSION COEFFICIENTS FOR PREDICTING PERCENT LEAN CUTS USING VARIOUS COMBINATIONS OF LIVE ANIMAL MEASUREMENTS TAKEN AT 154 DAYS OF AGE (1956)

Independent variables	R	Partial regression coefficients of percent lean cuts (Y) on: [a]								
		X_1	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
$X_1, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}$	0.71	0.06	−.13	0.42	−1.93	−5.73	−.07	−.08	0.28	−.25
X_1, X_4, X_5, X_6	.68	.04	...	0.49	−1.62	−7.40	...	...	....	...
X_1, X_5, X_6, X_9	.68	.04	...	....	−1.96	−7.88	...	...	0.34	...
X_1, X_5, X_6, X_{10}	.66	.08	...	....	−1.57	−7.77	...	...	....	−.21
$X_1, X_4, X_6,$	.67	.05	...	0.49	....	−9.58	...	...	....	...
$X_1, X_6, X_9,$	.67	.05	...	....	....	−10.51	...	...	0.32	...
$X_1, X_5, X_6,$	.66	.07	...	....	−1.59	−8.47	...	...	....	...
$X_1, X_6, X_{10},$	.65	.08	...	....	....	−9.86	...	...	....	−.21
X_1, X_6	.65	.07	...	....	....	−10.61	...	...	....	...

[a] Weight (X_1), width behind shoulders (X_3). length of foreleg (X_4), backfat at shoulder (X_5), backfat at loin (X_6), belly arc (X_7), circumference of shin (X_8), circumference of foreleg (X_9), width at loin (X_{10}).

addition of depth of chest (X_2), width behind the shoulders (X_3), length of foreleg (X_4) or backfat at the shoulder (X_5) to a prediction equation which already contains weight and loin backfat appears to add little to the accuracy of the prediction.

Regression analyses of the 1956 data showed that the variance explained by all nine of the independent variables was 50, 45, 36 and 13% for percent lean cuts, average carcass backfat, length of carcass and loin eye area, respectively. As in 1955, an attempt was made to determine the three or four measurements with the greatest value for predicting the carcass traits,

TABLE 4. MEANS AND STANDARD DEVIATIONS FOR MEASUREMENTS AT VARIOUS AGES (1957)

	Days of age							
	84[a]		112[b]		140[b]		154[b]	
Characteristic	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Weight, lb.	37.7	10.6	69.6	17.0	105.6	25.4	129.3	28.2
Width behind the shoulders, cm.	14.5	1.7	17.9	2.0	21.3	2.2	22.8	2.2
Width of loin, cm.	10.0	1.8	13.8	2.2	17.2	2.4	19.3	2.6
Circumference of shin, cm.	10.3	1.0	11.4	1.0	12.6	1.0	13.1	.9
Circumference of foreleg, cm.	15.6	1.6	19.6	1.8	23.2	2.3	24.2	2.6
Length of foreleg, cm.	16.9	1.7	20.2	1.4	22.7	1.5	23.6	1.4
Belly arc, cm.	48.8	5.3	60.6	5.9	69.4	5.8	74.3	5.7
Backfat at shoulder, in.	.6	.2	.9	.2	1.3	.3	1.5	.3
Backfat at loin, in.	.4	.1	.5	.1	.8	.2	1.0	.3
Percent lean cuts[c]	47.2	2.4	..	..	..	..	...	..
Loin eye area, sq. in.[c]	3.4	.4	..	..	..	..	...	..
Length of carcass, in.[c]	29.4	1.2	..	..	..	..	...	..

[a] Based on 132 animals measured at all ages.
[b] Based on 167 animals including 132 measured at 84 days.
[c] Carcass data based on 167 animals slaughtered at 210 pounds.

using percent lean cuts as the dependent variable in this screening process. These results are presented in table 3. Again, 154-day weight and backfat at the loin are the two measurements of highest value in predicting percent lean cuts. The addition of width behind the shoulders (X_3), length of foreleg (X_4), backfat at the shoulder (X_5) or circumference of foreleg (X_9) added little to the accuracy of the equation containing weight and backfat at the loin.

Measurements were taken at four ages in 1957 in an attempt to estimate the value of the developmental pattern in predicting carcass merit. The means and standard deviations for these measurements are presented in table 4.

Multiple correlation coefficients of carcass traits with live animal measurements taken at various ages indicate that carcass merit can be estimated as accurately at 112 days as at 154 days of age. This may not hold true, however, if the feeding regime is changed sufficiently to alter the growth curve. The multiple correlation of all live animal measurements with percent lean cuts was 0.37 at 84 days and approximately 0.5 at 112, 140 or 154

TABLE 5. MEANS AND STANDARD DEVIATIONS OF LIVE ANIMAL MEASUREMENTS AT TIME OF SLAUGHTER (POOLED WITHIN BREED AND SEX)

Characteristic	1955		1956	
	Mean	Standard deviation	Mean	Standard deviation
Depth of chest, cm.	38.1	0.3	....	...
Width behind shoulders, cm.	31.9	1.2	28.3	1.0
Length of foreleg, cm.	27.0	1.2	27.7	1.3
Backfat at shoulder, in.	2.0	0.2	2.3	0.3
Backfat at loin, in.	1.5	0.2	1.6	0.3
Belly arc, cm.	....	...	80.7	3.1
Circumference of shin, cm.	....	...	15.4	0.5
Circumference of foreleg, cm.	....	...	27.4	1.3
Width at loin, cm.	27.3	1.2	25.3	1.2
Width at ham, cm.	29.9	1.2	....	...

days. The changes in measurements between ages are not as accurate in predicting carcass merit as the absolute measurements at any of the ages used here. However, if these changes are used in combination with the measurements taken just prior to and/or with the measurements taken just after these changes occur, larger multiple correlations with the carcass traits are found than when either is used alone. In this sample, the measurements at 140 and 154 days of age combined with the changes in the measurements between these two ages provided the best indication of percent lean cuts (R=.61).

Prediction of Carcass Traits from Live Animal Measurements Taken at 205–225 Pounds. The means and standard deviations of the live animal measurements taken just prior to the 18-hour fasting period are given in table 5. Multiple correlation coefficients and partial regression coefficients

TABLE 6. MULTIPLE CORRELATION AND PARTIAL REGRESSION COEFFICIENTS FOR PREDICTING FOUR CARCASS TRAITS USING LIVE ANIMAL MEASUREMENTS AT TIME OF SLAUGHTER (1955)

Live measurement	Percent lean cuts	Loin eye area	Length of carcass	Average carcass backfat
	%	sq. in.	in.	in.
Depth of chest, cm.	—.01	—.01	—.03	0.03
Width behind shoulders, cm.	—.35	0.02	—.05	0.01
Length of foreleg, cm.	0.20	0.03	0.14	—.02
Backfat at shoulder, in.	—2.26	—.37	—.67	0.25
Backfat at loin, in.	—5.19	—.30	—.85	0.44
Width at loin, cm.	—.28	—.02	—.05	0.03
Width at ham, cm.	0.29	0.06	—.06	—.02
R	0.73	0.35	0.65	0.76

using all seven independent variables to predict the four carcass traits are presented in table 6 for the 1955 data. The average within sex and breeding group regression analysis for 1955 showed that the variance explainable by the seven independent variables was 53, 12, 42 and 58 percent for percent lean cuts, loin eye area, length of carcass and average carcass backfat respectively.

Multiple correlation coefficients of the magnitude obtained in this study are considered high enough to be of value in estimating percent lean cuts and carcass backfat. As in the 154-day measurement study, the two or three measurements giving the highest prediction for percent lean cuts were

TABLE 7. MULTIPLE CORRELATION AND PARTIAL REGRESSION COEFFICIENTS FOR PREDICTING FOUR CARCASS TRAITS USING LIVE ANIMAL MEASUREMENTS AT TIME OF SLAUGHTER (1956)

Live measurement	Percent lean cuts	Loin eye area	Length of carcass	Average carcass backfat
	%	sq. in.	in.	in.
Width behind shoulders, cm.	—.29	—.06	—.08	0.01
Length of foreleg, cm.	0.20	—.33	0.14	—.02
Backfat at shoulder, in.	—2.41	—.19	—.40	0.22
Backfat at loin, in.	—2.95	—.47	—.22	0.24
Belly arc, cm.	—.12	—.02	0.01	—.00
Circumference of shin, cm.	0.35	—.07	0.20	—.03
Circumference of foreleg, cm.	0.24	0.05	—.07	0.01
Width of loin, cm.	—.15	0.05	—.23	0.03
R	0.79	0.44	0.67	0.77

sought. Width behind the shoulders and backfat at the loin is the combination of two variables which has the greatest value in predicting percent lean cuts (R=0.69). Adding any one or combination of two of the remaining variables failed to increase the precision of this prediction equation.

In 1956, the depth of chest and width of ham measurements were discontinued and circumference of shin, circumference of foreleg and belly arc were added. The regression analyses, as shown in table 7, indicated that 63, 19, 45 and 59% of the variance in percent lean cuts, loin eye area, length of carcass and average carcass backfat, respectively, could be accounted for by the variance in all of the eight independent variables used in 1956.

An attempt was made to determine the combinations of two or three variables which have the hightest value in predicting percent lean cuts in the 1956 data. The correlation between a single backfat measurement and percent lean cuts was 0.66. If both backfat measurements were used the multiple correlation with percent lean cuts was 0.73. It appeared that little if any increase in precision was realized by including any one additional

measurement. Width behind the shoulder and belly arc appeared to hold the most promise in increasing the accuracy of prediction.

Discussion. Few attempts have been made to determine the value of individually recorded body measurements on live animals at early ages for predicting the quality and quantity of the components of a hog carcass. DePape and Whatley (1956) have shown significant correlations between the live backfat probes and carcass backfat at relatively early ages. These correlations increased with increasing age. The data in the present study indicated that carcass merit, measured in terms of percent lean cuts and carcass backfat, can be estimated as well at 112 days of age as at 154 days.

If length of foreleg, circumference of foreleg and backfat probes taken on the live animal can be assumed to be measures of skeletal growth, muscular development and fat deposition, respectively, these data (table 4) indicate that each of these attributes attains maximum rate of development at a successively later stage. That is, major skeletal formation has been completed by 112 days whereas rate of muscle development did not decrease until 112 to 140 days and rate of fat deposition in these hogs was still increasing between 140 and 154 days of age. (Note that the period 140 to 154 days is only one-half as long as each of the other two periods.) These conclusions appear to be in general agreement with McMeekan (1940, 1941).

The weight-for-age of the animals used in this study was somewhat lower than the average for the animals in the Wisconsin Swine Selection Cooperative, which should reflect average farm results for the state. It would seem advisable, in applying these results to other herds, to measure the animals when they reach an average weight comparable to the weights in this study, regardless of age. These data indicate that live animal measurements at relatively early ages can be used to predict percent lean cuts with some precision.

The work of Phillips *et al.* (1939), Bogart *et al.* (1940), Hetzer *et al.* (1950), Bratzler *et al.* (1953) and Heidenreich *et al.* (1955) has shown that various live hog scores and body measurements, recorded just prior to slaughter are significantly correlated with percent primal cuts and percent lean meat in hams, but the correlations are not large. Hazel and Kline (1952, 1953), DePape and Whatley (1956) and Hetzer *et al.* (1956) have reported correlations between live backfat probe at time of slaughter and percent lean cuts of approximately —.70. They concluded that the live probe was at least as accurate as the carcass backfat in predicting percent lean cuts. Pearson *et al.* (1957) have indicated that there is little difference in the usefulness of the metal ruler probe and the lean meter in regard to estimating percent lean cuts.

In this study when the animals were measured at 154 days of age, weight and backfat were the most important measurements for predicting carcass merit at 210 lb. Apparently little increase in the precision of predicting percent lean cuts will be realized by including additional body measure-

ments in an equation containing backfat and weight. The measurements holding most promise of increasing precision when used in conjunction with backfat and weight for predicting carcass merit were length of foreleg, circumference of foreleg, width behind the shoulders or width of loin.

When the measurements were taken just prior to slaughter and at a rather constant weight, backfat probes were the best single measures of carcass merit. Width behind the shoulders showed some promise of being useful for increasing the precision of predicting carcass merit.

Summary

Live animal measurements at 154 days of age and carcass information were obtained on 663 animals during the period 1955–1957, inclusive. Measurements were taken just prior to slaughter on 496 animals. In 1957 live animal measurements were taken at 84, 112, 140 and 154 days of age on 167 animals. An initial study of splitting and cutting errors in hog carcasses indicated that only one side need be cut to yield reliable data.

These data indicate that measurements on live animals at 112 to 154 days of age may be used with a reasonable degree of reliability for predicting percent lean cuts at a subsequent slaughter weight of 205–225 lb. Backfat at the loin and body weight were the best indicators of carcass merit. There were indications that some increase in precision might be realized by including additional body measurements.

When the measurements were taken at a fairly constant weight, just prior to slaughter, apparently some increase in accuracy was obtained by adding body measurements to an equation containing backfat probes at the shoulder and loin.

Literature Cited

Bogart, R., L. A. Weaver and J. E. Comfort. 1940. Carcass studies including scores, measurements and yields. Regional Swine Breeding Laboratory Research Item No. 17.

Bratzler, L. J. and E. P. Margerum, Jr. 1953. The relationship between live hog scores and carcass measurements. J. Animal Sci. 12:856.

DePape, J. G. and J. A. Whatley, Jr. 1956. Live hog probes at various sites, weights and ages as indicators of carcass merit. J. Animal Sci. 15:1029.

Fifth Ann. Reciprocal Meats Conference Proc. 1952. Chicago, Illinois.

Hazel, L. N. and E. A. Kline. 1952. Mechanical measurement of fatness and carcass value on live hogs. J. Animal Sci. 11:313.

Hazel, L. N. and E. A. Kline. 1953. Accuracy of eight sites for probing live pigs to measure fatness and leanness. J. Animal Sci. 12:894 (Abstract).

Heidenreich, C. J., J. F. Lasley, D. E. Brady and L. F. Tribble. 1955. The relative importance of various live-hog measurements in predicting carcass value. J. Animal Sci. 14:1183 (Abstract).

Hetzer, H. O., O. G. Hankins, J. X. King and J. H. Zeller. 1950. Relationship between certain body measurements and carcass characteristics in swine. J. Animal Sci. 9:37.

Hetzer, H. O., J. H. Zeller and O. G. Hankins. 1956. Carcass yields as related to live hog probes at various weights and locations. J. Animal Sci. 15:257.

Lasley, E. L. and E. A. Kline. 1957. Splitting and cutting errors in swine carcass evaluation. J. Animal Sci. 16:485.

McMeekan, C. P. 1940. Growth and development in the pig with special reference to carcass quality characters. J. Agr. Sci. 30:276; 387; 511.

McMeekan, C. P. 1941. Growth and development in the pig with special reference to carcass quality characters. J. Agr. Sci. 31:1.

Pearson, A. M., J. F. Price, J. A. Hoefer, L. J. Bratzler and W. T. Magee. 1957. A comparison of the live probe and lean meter for predicting various carcass measurements of swine. J. Animal Sci. 16:481.

Phillips, R. W., H. O. Hetzer and R. L. Hiner. 1939. Relation of scores of swine to carcass yields and certain carcass measurements. Regional Swine Breeding Laboratory Research Item No. 15.

Self, H. L., R. W. Bray and R. J. Reierson. 1957. Lean cut yield and an evaluation of hams and loins of U.S.D.A. pork carcass grades. J. Animal Sci. 16:642.

SWINE SELECTION INDEXES INCLUDING LIVE ANIMAL MEASUREMENTS AS INDICATORS OF CARCASS MERIT [1]

O. W. ROBISON,[2] A. B. CHAPMAN AND H. L. SELF [3, 4]

University of Wisconsin, Madison

THE decreased demand for lard and the decline in consumption of pork cuts in relation to other meats are indications that a different type of hog carcass is needed. In general, it is agreed that a leaner, more muscular type of hog is desired by the public. Regardless of whether the producer receives a price differential based on the carcass desirability of his pigs, it is imperative to the future welfare of the swine industry, if it is to meet the competition from other products, that hogs yielding highly acceptable pork products be marketed. This responsibility lies with the purebred and commercial swine producers who, in turn, depend on research to recommend proper methods of selection for improving their herds. To be acceptable and useful these methods must be not only effective but also relatively simple.

Hazel (1943) and Karam *et al.* (1953) have presented detailed procedures for constructing selection indexes and Hazel (1943) and Bernard *et al.* (1954) have developed indexes for swine. These indexes do not, however, utilize body measurements in identifying superior genetic stock nor do they include carcass merit in the aggregate genetic value.

The purpose of the present study was to develop a selection index utilizing body measurements taken at 154 days of age combined with measures of production traits. A description of the animals used and of the slaughtering, cutting and measuring procedures has been reported in a previous paper (Robison *et al.*, 1960).

Results

Relative Economic Importance. It was assumed that profitability in a swine enterprise could be defined in terms of rate of gain, productivity and carcass quality as measured by weight-for-age, number of pigs raised per litter and percent lean cuts, respectively. The procedure followed here was to compare the increase in net income from one unit change in each of the last three traits.

The average litter size at 154 days in the Wisconsin Swine Selection Cooperative in 1957 was 7.7 and the average individual pig weight at 154

[1] Paper from the Department of Genetics No. 785 and the Department of Animal Husbandry, Univ. of Wisconsin in cooperation with the Regional Swine Breeding Laboratory, AHRD, ARS, U. S. Department of Agriculture. Published with the Approval of the Director of the Agricultural Experiment Station.

[2] Present address: Department of Animal Industry, North Carolina State College, Raleigh, North Carolina.

[3] Present address: Department of Animal Husbandry, Iowa State University, Ames, Iowa.

[4] The authors wish to acknowledge the cooperation of Oscar Mayer & Company, Madison, in obtaining the carcass data.

days was 154 lb. Under these conditions an increase of one pound in weight for each pig in a litter at 154 days of age would be equivalent to an increase of 0.05 pig per litter. Hence, one additional pig per litter is worth as much in terms of net profit as 20 lb. additional in 154-day weight per pig. The assumption that a given increase in amount of pork produced may be obtained at the same cost either by increasing the average litter size or by increasing the weight of each pig appears to be approximately correct (Bernard *et al.*, 1954; Haver, 1954).

The average wholesale price per hundredweight of lean cuts from 1947–1956 at Chicago was $42.54 (range $35.73–$48.18). The average for all other parts of the dressed carcass was $23.06 (range $15.87–$32.49) per cwt. This results in an average difference of $19.48 per cwt. of carcass. Thus, on a carcass of average weight (150 lb.) an increase of one percent in lean cuts would result in an increased carcass value of 29 cents, assuming no increase in cost of production or processing due to this increase in percent lean cuts.

The average price of live hogs weighing 200–220 lb. was $21.05 (range $15.33–$26.32) per cwt. Just prior to 154 days of age the average pig requires approximately 3.5 lb. of feed per pound of gain. Based on the average prices ($2.90/cwt.) for feedstuffs most commonly fed in the corn belt, it would cost 10.15 cents to produce a pound increase in weight. Thus net income realized from an increase of 20 lb. in live weight is $2.18 (20 lb. @ $21.05/cwt. minus 20 lb. @ $10.15/cwt.) Therefore, an increase of 7.5 percent lean cuts would result in approximately the same net income (7.5 @ 29 cents) as an increase of 20 lb. in individual pig weight.

These figures would suggest that the relative economic values should be 1:2.67:20 for individual pig weight at 154 days, percent lean cuts and litter size at 154 days, respectively. Bernard *et al.* (1954) and Haver (1954) agree with the relative economic values presented here for individual weight and litter size. Indexes were also calculated using relative economic values of 1:5.88:20 and 1:1.92:20. This range in relative economic values changes the final index only slightly.

Comparison of Two Methods of Constructing Selection Indexes. Details for constructing selection indexes have been outlined by Hazel (1943) and Karam *et al.* (1953). With a given set of parameters both lead to the same index. However, the Karam *et al.* (1953) index contains a modification suggested by Henderson (1951). This allows an easier modification of the index when a change in the relative economic values occurs. Among the statistics needed to construct an index by this general method are genetic correlations and heritabilities (method A).

Estimating the genetic correlations among traits by correlating one trait in the dam with (p'_i or p'_j) another in the offspring (p_j or p_i) was proposed by Hazel (1943). The formula is $r_{G'_iG'_j}=\sqrt{r_{p_ip'_j}r_{p'_ip_j}/r_{p_ip'_i}r_{p_jp'_j}}$. This formula appears to be valid for the conditions postulated by the author, but for traits influenced by maternal environment the expectation is not $r_{G'_iG'_j}$.

Rather, the expectation is a complex function of the genetic correlation between traits, the direct effect of maternal environment and the correlation between genotypes for maternal environment and the traits in question, as suggested by Koch and Clark (1955a, b).

Figure 1 is a path diagram illustrating possible relationships involved in the correlation of offspring with dam. In order to simplify the diagram, the paths for non-maternal environmental influences are not shown. They would further complicate the formula for the expectation of the correlation coefficient. Similar complexities enter into the estimation of heritabilities

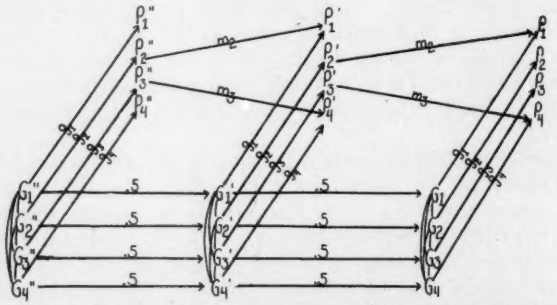

Figure 1. Relationships between offspring, dam (single prime) and maternal grandam (double prime) where P represents phenotypic expression and G represents genotype. 1=size of litter at 154 days; 2=maternal environment most closely associated with litter size; 3=maternal environment most closely associated with individual weight; 4=individual weight at 154 days of age.

based on doubling the parent-offspring correlation. That is, $2\ r_{p'_1p_1} = g^2_1 + m^2_1 g^2_1 + 2.5\ m_1 g_2 g_1 r_{g_1 g_2}$. These arguments point to the fact that, in any set of data not suited to obtaining estimates of maternal effects, the estimates of heritabilities and genetic correlations may be biased.

The method proposed here is one where the multiple regression technique utilizes the phenotypic information available on the parent to predict the aggregate phenotypic economic value of the progeny directly (method B). Progeny economic value (V) is determined as follows: $V = \Sigma(a_i X_i)$ where the a_i is the relative economic value for the i^{th} trait (X_i). Since maternal effects are included in the prediction, the assumptions about, and separate estimates of, these effects are avoided. This would appear to be a more practical method of developing a selection index in the sense that it is easier to calculate, does not require estimates of parameters for which suitable data are not always available and bases the prediction on the single overall value of the offspring produced rather than calculating several statistics,

each with its own error, and combining them (method A). Method B would be expected to provide the same index as method A if all of the phenotypic, environmental and genetic parameters were known. Method B appears to represent the realized heritability of an index calculated by method A. One advantage of method A is that the constants involved are available for other uses.

For purposes of comparing the two methods of calculating indexes, the number of pigs in the litter at 154 days and the weight of the individual at 154 days were used. Estimates of heritabilities for use in constructing an index by method A were computed. These estimates were 0.20 and 0.40 for litter size and individual weight, respectively. The estimate of the genetic correlation between these two traits was 0.24. The estimate of the correlation of the index on the dam with the index on her progeny by method A is 0.16 whereas the comparable correlation of information on the dam with "economic value" on her progeny (method B) is 0.22. This comparison indicates that, on these data, the indexes led to similar results.

Calculation of Proposed Indexes. Information available on the dam, at 154 days of age, for use in predicting the performance of her progeny as indicated by the economic value index given previously, included weight (X_1), depth of chest (X_2), width behind the shoulders (X_3), length of foreleg (X_4), backfat at the shoulders (X_5), and backfat at the loin (X_6). Data on the litter in which the dam was raised were number of pigs farrowed (X_7), number of pigs in litter at 154 days (X_8) and weight of litter at 154 days (X_9).

The intra-sire regression of progeny "economic value" on the dam's information gave a multiple correlation of $0.34 \pm .14$. A comparable figure, that is the expected value for the correlation of the index of a dam, in the studies of Hazel (1943) and Bernard *et al.* (1954) would be about 0.08. More traits are, however, used in the present study.

Four indexes were calculated to predict progeny "economic value" from the dam's phenotype:

(a) an index using all the information available on the dam at 154 days
$I_a = 0.062\ X_1 + .243\ X_2 - .314\ X_3 - .407\ X_4 - 1.805\ X_5 - 2.564\ X_6 + 0.127\ X_7 - 0.154\ X_8 - 0.000\ X_9$.

(b) an index using individual weight (X_1), width behind the shoulders (X_3), length of foreleg (X_4), backfat at loin (X_6), number in litter at farrowing (X_7) and number in litter at 154 days (X_8).
$I_b = .072\ X_1 - .238\ (X_3) - .446\ (X_4) - 4.408\ (X_6) + .107\ X_7 - .156\ X_8$.

(c) an index using individual weight (X_1), width behind the shoulders (X_3), backfat at loin (X_6), number in litter at farrowing (X_7) and number in litter at 154 days (X_8).
$I_c = .047\ X_1 - .162\ X_3 - 3.383\ X_6 + .064\ X_7 - .109\ X_8$.

(d) an index using individual weight (X_1), length of foreleg (X_4), backfat at loin (X_6), number in litter at farrowing (X_7) and number in litter at 154 days (X_8).
$I_d = .054\ X_1 - .403\ X_4 - 4.334\ X_6 + .123\ X_7 - .204\ X_8$.

The permanent improvement accomplished by selection is in proportion to the accuracy with which genetic differences among animals can be recognized. Since genotypes cannot be evaluated directly, selection must be practiced for estimates of the genotype based on measurable characteristics. Consequently, the multiple correlations of progeny "economic values" with the dams' information used in each index provide a logical basis for comparing the efficiency of these different measures. These multiple correlations are 0.34, 0.33, 0.28 and 0.32 for I_a, I_b, I_c and I_d, respectively.

Discussion. The index which best depicts the aggregate genetic merit of individual pigs is I_a. It is only slightly superior, however, to I_d. Because I_d utilizes fewer measurements and sacrifices only a little in precision, it seems to be the most practical. However, deletion of any one of the traits in I_d sharply decreases the correlation between index and aggregate genetic value. For this reason indexes with fewer variables than I_d are not presented. In order to facilitate calculations this index may be simplified to: $I'_d = 164 + .5\ X_1 - 4\ X_4 - 43.3\ X_6 + 1.2\ X_7 - 2\ X_8$.

These indexes differ from those commonly in use in that they utilize live animal measurements in the prediction of aggregate genetic value which is composed not only of measures of rate of gain and of sow productivity but also of estimates of carcass desirability.

I_d indicates that increased live animal backfat, with other measures held constant, is undesirable. One reason for this is the decrease in the percent of lean cuts of the progeny if backfat is increased while length of foreleg and weight are constant. While in general this decrease in backfat will improve carcass merit, it must be remembered that a minimum backfat is probably necessary to maintain firmness and quality of the carcass. Fatter gilts are likely to have a higher embryonic mortality rate (Self *et al.*, 1955). Dickerson (1947) suggests that genetically fatter gilts are probably poorer milkers, thus providing poorer maternal environment. The studies of Hankins (1940), Hetzer and Brier (1940), Phillips and Zeller (1943) and Zeller (1940) provide additional evidence for genetically greater fat deposition being associated with poorer suckling ability, as well as with lower fertility, poorer prenatal nutrition and higher mortality.

The weight of a pig at 154 days, under the conditions of this study, would seem to be indicative of the gaining ability of its offspring. Since backfat and length of foreleg are largely measures of fat and bone, respectively, an increase in weight, with these measurements held constant, is probably due to an increase in muscling and hence would result in an increase in the percent of lean cuts.

The index indicates that, with other measurements held constant, a decrease in length of foreleg is desirable. Additional information, equations for

predicting specific traits of the aggregate genetic value, shows that a decrease in length of foreleg results in a larger litter size and in progeny that produce a higher percent of lean cuts.

The fact that the index places negative emphasis on litter size at 154 days for the litter from which the gilt came, when other factors are held constant, appears to contradict the fact that increasing the litter size at 154 days is one of the goals of the index. Differential mortality from farrowing to 154 days between two litters of the same size at farrowing may not be a genetic characteristic of the dam but indicative of the adverse environment to which the litter has been subjected. Therefore, a gilt which overcomes this more adverse environment may perform as well as one subjected to a better environment due to having a stronger constitution and hence is better suited for production.

The proposed index is based on data from purebred and crossbred stock. Progeny "economic value" information is from gilts producing their first litters and is, therefore, specifically applicable to gilt litters. Because of the small numbers available for calculation of the index and of their low weight for age, further investigation of the index is needed. It may be that other measurements should be added or substituted for those now included to give more accurate progeny predictions. Since the only litter information needed is number of pigs farrowed and raised, barrows need not be measured. This would expedite obtaining the data needed for selection purposes.

The relative economic values used are approximations from economic statistics and not from experimental data. Hence, more precise information as to relative economic values should add precision to the selection index. Relative economic values for various breeds should be studied also to learn if breed differences exist for these statistics. One breed may, for example, be high in productivity but low in carcass merit, another low in productivity but high in carcass merit. However, because of the small change in the index when extremes of relative economic values are used, the proposed index should be helpful in the selection of breeding stock even though there is uncertainty concerning exact estimates of relative economic values.

Summary

Estimates of heritability were obtained by doubling the intra-sire daughter-dam regression. These estimates were 0.20 and 0.40 for number of pigs in a litter at 154 days and individual pig weight at 154 days, respectively. The genetic correlation between these traits was estimated to be 0.24. Theoretical aspects of the biases of these estimates when maternal environment is involved are presented.

The method of Hazel, as modified by Henderson, for constructing a selection index was compared to a prediction of a single estimate of progeny "economic value" from the dam's phenotype. The relative economic values of a unit change in individual pig weight at 154 days of age, percent lean

cuts, and litter size at 154 days, in terms of net income, were estimated at 1:2.67:20, respectively. The estimate of the correlation of the index on the dam with the index on her progeny by the former method is 0.16 whereas the comparable correlation of information on the dam with "economic value" on her progeny is 0.22. Comparison of the two methods by these correlations indicates that they lead to essentially the same results. The latter method appears to be more practical since it is easier to calculate and data suitable for calculation of the index are more readily available. Also, it predicts the overall merit of the offspring rather than requiring separate estimates of the components, each with its own error.

The index proposed for practical use appears not to be quite as accurate as others calculated in this study but has the advantage of containing fewer variables and requiring that potential breeding stock only (boars and gilts available for selection) be measured. The proposed index is: $I'_a = 164 + .5\ X_1 - 4\ X_4 - 43.3\ X_6 + 1.2\ X_7 - 2\ X_8$. It is based on individual weight (X_1, lb.), length of foreleg (X_4, cm.), backfat at the loin (X_6, in.), number in litter at farrowing (X_7) and number in litter at 154 days (X_8).

Literature Cited

Bernard, C. S., A. B. Chapman and R. H. Grummer. 1954. Selection of pigs under farm conditions: kind and amount practiced and a recommended selection index. J. Animal Sci. 13:389.

Dickerson, G. E. 1947. Composition of hog carcasses as influenced by heritable differences in rate and economy of gain. Ia. Agr. Exp. Stat. Res. Bul. 354.

Hankins, O. G. 1940. A study of carcass characteristics in relation to type of hog. Amer. Soc. Anim. Prod. Proc. 1940:284.

Haver, C. B. 1954. Economic aspects of hog production in North Dakota. N. Dak. Agr. Exp. Stat. Bul. 391.

Hazel, L. N. 1943. The genetic basis for constructing selection indexes. Genetics 28:476.

Henderson, C. R. 1951. Mimeographed. Cornell University, Ithaca, New York.

Hetzer, H. O. and G. W. Brier. 1940. Extent to which type differences among swine affect litter size. Amer. Soc. Anim. Prod. Proc. 1940:135.

Karam, H. A., A. B. Chapman and A. L. Pope. 1953. Selecting lambs under farm conditions. J. Animal Sci. 12:148.

Koch, R. M. and R. T. Clark. 1955a. Genetic and environmental relationships among economic characters in beef cattle. II. Correlations between offspring and dam and offspring and sire. J. Animal Sci. 14:786.

Koch, R. M. and R. T. Clark. 1955b. Genetic and environmental relationships among economic characters in beef cattle. III. Evaluating maternal environment. J. Animal Sci. 14:979.

Phillips, R. W. and J. H. Zeller. 1943. Sexual development in small and large types of swine. Anat. Rec. 85:387.

Robison, O. W., J. H. Cooksey, A. B. Chapman and H. L. Self. 1960. Estimation of carcass merit of swine from live animal measurements. J. Animal Sci. 19:1013.

Self, H. L., R. H. Grummer and L. E. Casida. 1955. The effects of various sequences of full and limited feeding on the reproductive phenomena in Chester White and Poland China gilts. J. Animal Sci. 14:573.

Zeller, J. H. 1940. Swine type as a factor in pork production. Amer. Soc. An. Prod. Proc. 1940:279.

EFFECT OF SIZE OF GRIND AND LEVEL IN THE RATION OF DEHYDRATED ALFALFA MEAL, OF TRACE MINERALS AND AN IMPLANTED TRANQUILIZER ON THE PERFORMANCE OF FATTENING LAMBS [1, 2, 3]

T. W. PERRY, R. C. HOLZ, W. H. SMITH, W. M. BEESON AND M. P. PLUMLEE

Purdue University Agricultural Experiment Station, Lafayette, Indiana

PERRY *et al.* (1959) reported that the substitution of a variety of roughages for ground corn cobs in a 60% roughage pellet did not improve the performance obtained by feeding fattening lambs a complete mixed pelleted ration of the following percentage composition: ground corn cobs, 40; dehydrated alfalfa meal, 20; ground yellow corn, 29.5; soybean meal, 7; molasses distillers solubles, 2; and bonemeal and iodized salt. Furthermore, growth was not improved by lowering the roughage content of the pellet to 40%; neither was it improved by increasing the energy content by adding 7.5% grease nor by substituting either skimmilk or fish meal for the soybean oil meal on a protein equivalent basis.

Additional research on modifications which might improve performance obtained from feeding the complete mixed pelleted ration involved the following comparisons: (1) the value of grinding the dehydrated alfalfa meal contained in the pellet to various degrees of fineness; (2) the value of 20% dehydrated alfalfa meal vs. 40% dehydrated alfalfa meal; (3) the value of adding trace minerals and vitamin B_{12}; and (4) the value of implanting two levels of a tranquilizer.

Experimental Procedure

Two hundred and forty feeder lambs that had been wormed, sprayed, ear tagged and paint branded were divided into 12 lots of 20 each on the basis of sex, liveweight and apparent thrift. The lambs were fed their respective complete mixed pelleted ration on a full-feed basis from the first day.

The 12 lots of 20 lambs each were assigned to the 12 treatments of a 2 x 2 x 3 factorial design involving two levels of dehydrated alfalfa, with and without trace minerals and three degrees of fineness of grind of the meal. The basal ration consisted of ground corncobs, 39.5%; dehydrated alfalfa meal, 20%; ground yellow corn, 32%; soybean meal, 7%; bone

[1] Contribution from the Department of Animal Science, Journal Paper No. 1578, Purdue University, Lafayette, Indiana.

[2] The research reported in this paper was supported in part by a grant in-aid from the Smith-Kline-French Laboratories, Philadelphia, Pennsylvania.

[3] The alfalfa meal used was furnished by the W. J. Small Division, Archer-Daniels-Midland Company, Minneapolis, Minnesota.

meal, 1%; iodized salt, 0.5% and vitamin A and D. The three sizes of grind of the alfalfa meal were 3/64-, 1/4- and 1/2-inch.

The trace minerals and vitamin B_{12} were incorporated at the following levels: manganese, 40 ppm; cobalt, 0.44 ppm; copper, 6.6 ppm; iron, 80 ppm; zinc, 50 ppm; and, vitamin B_{12}, 7.5 mcg. per lb.

Five lambs in each lot were initially implanted subcutaneously with one 5-mg. pellet of trifluomeprazine; five were initially implanted with two 5-mg. pellets; five were implanted with two 5-mg. pellets on the 42nd day of the experiment; and, five in each lot were not implanted.

One lot of lambs from the six lots not receiving trace minerals and vitamin B_{12} and one lot from the six lots fed trace minerals and vitamin B_{12} each were bled from the ear for hemoglobin determination on the 7th, 21st, 35th, 47th, 54th and 61st days, respectively. By following this program, all lots of lambs were bled only one time but by bleeding comparable lots throughout the experimental period progressive changes could be detected.

Results and Discussion

Effect of Size of Grind. The size of grind of the dehydrated alfalfa meal contained in the complete mixed pelleted ration had no effect on its nutritional value when measured in terms of daily gain, feed efficiency or quality of carcasses produced. Similarly, the size of grind apparently had no effect

TABLE 1. EFFECT OF LEVELS OF DEHYDRATED ALFALFA MEAL IN A FEEDER LAMB PELLET

Lot number and treatment	Lots 1, 2, 3, 7, 8, and 9 20% dehy.	Lots 4, 5, 6, 10, 11, and 12 40% dehy.
No. of lambs	119	120
Growth and feed data, lb.		
Initial weight	74.7	74.3
Final weight	104.5	106.0
Total gain	29.8	31.7[a]
Average daily gain	0.49	0.52
Pellets per day	4.45	4.33
Pellets/100 lb. gain	913	831
U. S. carcass grade[b]		
High choice, no.	14	32
Average choice, no.	25	38
Low choice, no.	36	36
High good, no.	40	13
Average good, no.	4	1

[a] Lambs whose ration contained 40% dehydrated alfalfa meal gained significantly faster ($P<0.05$) than those whose ration contained 20% dehydrated alfalfa meal.

[b] When the carcass grades were assigned a numerical value (high choice 9, average choice 8, low choice 7, high good 6, average good 5) carcasses from lambs fed the 40% level of dehydrated alfalfa meal in their pellet graded significantly higher ($P<0.01$) than those from lambs fed the 20% level of dehydrated alfalfa meal in their pellet.

TABLE 2. EFFECT OF TRACE MINERALS AND VITAMIN B_{12} IN A FEEDER LAMB PELLET

Lot number and treatment	Lots 1, 2, 3, 4, 5 and 6 No trace minerals		Lots 7, 8, 9, 10, 11 and 12 Mn, Co, Cu, Fe, Zn, B_{12}	
No. of lambs	120		119	
	Females	Castrate males[a]	Females	Castrate males[a]
Growth and feed data, lb.				
Initial weight	72.7	76.8	72.5	76.8
Final weight	103.4	106.9	102.2	109.8
Total gain	30.7	30.1	29.7	33.0
Average daily gain	0.50	0.49	0.49	0.54
Pellets per day	4.38		4.40	
Pellets/100 lb. gain	879		862	
U. S. carcas grades				
High choice, no.	26		20	
Average choice, no.	27		36	
Low choice, no.	40		32	
High good, no.	23		30	
Average good, no.	4		1	
Hemoglobin levels, gm. %				
7th day	12.7 (Lot 1)		12.2 (Lot 7)	
21st day	11.1 (Lot 2)		11.8 (Lot 8)[b]	
35th day	11.6 (Lot 3)		11.6 (Lot 9)	
47th day	12.1 (Lot 4)		11.8 (Lot 10)	
54th day	12.0 (Lot 5)		11.7 (Lot 11)	
61st day	11.8 (Lot 6)		11.6 (Lot 12)	

[a] Castrate males fed trace minerals and vitamin B_{12} gained signficantly more ($P<0.05$) than the females on the same treatment.

[b] Hemoglobin level for lot 8 significantly greater ($P<0.05$) than for corresponding lot 2.

on palatability since lambs on the three grinds consumed similar amounts of feed.

Effect of Level of Dehydrated Alfalfa Meal. Lambs fed the pellet containing 40% dehydrated alfalfa meal and 20% cobs gained significantly more ($P<0.05$) than those fed the pellet containing 20% dehydrated alfalfa meal and 40% cobs (table 1). Although the apparent difference between the two groups is small, the large number of animals in each group combined with consistent response was adequate to make the difference statistically significant. The reason for this is not known, but dehydrated alfalfa meal is usually considered to be a higher quality roughage than corn cobs. When the carcass grades were assigned a numerical value (high choice 9, average choice 8, low choice 7, high good 6, average good 5) carcasses from lambs fed the 40% level of dehydrated alfalfa meal in their pellet graded significantly higher ($P<0.01$) than those from lambs fed the 20% level.

Effect of Trace Minerals and Vitamin B_{12}. The incorporation of the trace minerals, manganese, cobalt, copper, iron and zinc and of vitamin B_{12} was of no apparent advantage (table 2). The control lambs which did not

receive the supplemental trace minerals and vitamin B_{12} gained as rapidly and efficiently as those that did. Hemoglobin values obtained periodically showed no apparent advantage for the trace mineral and B_{12} supplementation except that on the 21st day the average level for the lambs in lot 8 (trace minerals and B_{12}) was significantly higher ($P<0.05$) than for the lambs in lot 2. In all five of the other comparisons there were no significant differences. However, dehydrated alfalfa meal is an excellent source of many of the trace minerals and thus an adequate supply may have been furnished to the first six lots of lambs in their natural ration.

TABLE 3. EFFECT OF IMPLANTED TRIFLUOMEPRAZINE UPON RATE OF GAIN AND CARCASS GRADES OF FEEDER LAMBS

Level of implant	Control No implant	Initial 5-mg. implant	Initial 10-mg. implant	Implant 10 mg. 42 day
No. lambs	59	60	60	60
Growth data, lb.				
Initial weight	75.6	73.1	76.1	73.2
Final weight	105.6	102.4	107.8	105.3
Total gain	30.0	29.3	31.7[a]	32.1[a]
Average daily gain	0.49	0.48	0.52	0.53
U. S. carcass grade				
High choice, no.	10	11	18	7
Average choice, no.	15	12	18	18
Low choice, no.	24	14	12	22
High good, no.	9	21	12	11
Average good, no.	1	2	..	2

[a] Lambs subcutaneously implanted with 10 mg. trifluomeprazine, either at the start of the experiment or on the 42nd day, gained significantly more ($P<0.05$) than the unimplanted controls or those implanted with 5 mg.

The castrate males gained significantly more ($P<0.05$) than the females on the trace mineral, B_{12} supplemented ration (33.0 vs. 29.6 lb. gain per lamb) but there was no sex difference on the ration not supplemented with trace minerals and vitamin B_{12}. Perry *et al.* (1959a) reported a sex difference in which the castrate males gained significantly more than the intact females, either with or without 3 mg. of implanted diethylstilbestrol.

Effect of Implanted Trifluomeprazine. The subcutaneous implantation of 10 mg. of trifluomeprazine either at the start of the trial or on the 42nd day, resulted in a significant increase in rate of gain ($P<0.05$) (table 3). Implanting 5 mg. of the tranquilizer had no apparent effect on gain. Since each of the four implanted tranquilizer treatments were tested within each lot, no data on feed consumption or feed efficiency were available. Perry *et al.* (1959a) reported there was no significant effect on the growth rate of feeder lambs by feeding either 5 mcg. or 10 mcg. daily of reserpine or by feeding 1 or 2 mg. daily of hydroxyzine. Similarly, Woolfolk *et al.* (1959) reported no apparent benefit from feeding 2.5 mg. hydroxyzine per

lamb daily. In contrast, Hale *et al.* (1959) obtained a 29% increase in gain from the feeding of 1.2 to 2.0 gm. of hydroxyzine per ton of ration.

Summary

Research was conducted to determine the effect of size of grind of dehydrated alfalfa meal, level of dehydrated alfalfa meal and the addition of trace minerals and vitamin B_{12} to a pelleted feeder lamb ration consisting of 60% roughage, 32% ground yellow corn, 7% soybean oil meal, 1% bonemeal, 0.5% iodized salt and vitamin A and D.

The size of grind of the dehydrated alfalfa meal ($\frac{3}{64}$", $\frac{1}{4}$" and $\frac{1}{2}$") had no effect on performance of fattening lambs, except that the hemoglobin level was significantly higher ($P<0.05$) for lambs fed the $\frac{3}{64}$" grind of dehydrated alfalfa meal in their pellet (12.21 gm. %) than for lambs fed either of the two coarser grinds in their pellet (11.64 gm. %).

Lambs whose pellet contained 40% dehydrated alfalfa meal and 20% ground corn cobs gained significantly faster ($P<0.05$) than those whose pellet contained 20% dehydrated alfalfa meal and 40% ground corn cobs.

Carcasses from lambs fed the 40% level of dehydrated alfalfa meal in their pellet graded significantly higher ($P<0.01$) than those from lambs fed the 20% level.

The addition of the trace minerals, manganese, cobalt, copper, iron and zinc and of vitamin B_{12} had no overall effect on growth rate or level of hemoglobin. However, castrate males fed the trace minerals and B_{12} gained significantly more than the females on the same ration.

The subcutaneous implantation of a 10-mg. pellet of trifluomeprazine, either at the start of the trial or on the 42nd day of the trial, resulted in a statistically significant increase in gain ($P<0.05$). A 5-mg. implant had no effect. None of the tranquilizer treatments tested had an apparent effect on carcass quality.

Literature Cited

Hale, W. H., W. C. Sherman, P. P. Appel, W. M. Reynolds and H. G. Luther. 1959. The effect of low-level diethylstilbestrol implantation, oxytetracycline and hydroxyzine on fattening lambs. J. Animal Sci. 18:710.

Perry, T. W., W. M. Beeson, M. H. Kennington and Claude Harper. 1959. Pelleted complete mixed rations for feeder lambs. J. Animal Sci. 18:1264.

Perry, T. W., Martin Stob, F. N. Andrews and W. M. Beeson. 1959a. The effect of diethylstilbestrol, reserpine, hydroxyzine and hygromycin on growth and carcass quality of lambs. J. Animal Sci. 18:227.

Woolfolk, P. C., L. H. Boyd, B. J. Greiman and T. J. Davidson. 1959. Pasture and drylot fattening of lambs with and without tranquilizer. J. Animal Sci. 18:1158 (Abstract).

MEASUREMENT OF AND WAYS OF AFFECTING SEX-INFLUENCED PERFORMANCE OF GROWING-FINISHING SWINE [1]

V. R. CAHILL, H. S. TEAGUE, L. E. KUNKLE, A. L. MOXON AND E. A. RUTLEDGE [2, 3]

Ohio Agricultural Experiment Station, Wooster, Ohio

RECOGNIZED goals of swine production include increased muscling, decreased amount of fat, and such quality factors that make pork desirable for processing and eating. Gross observation of pork carcasses and of swine during growth indicates sex-associated differences of both desirable and undesirable characters. If the performance of swine differs with sex, curiosity encourages the question as to the stage of development at which differences occur and the ways of favorably influencing carcass development.

The phases of the experiment reported here were designated to show swine development by sex and the influence of stilbestrol implanted at various levels.

Experimental Procedure

Three phases of this project have been conducted since the autumn of 1957, with Durocs from the Station herd. These hogs were grown indoors on concrete floors and received rations of the following percentage composition up to 120 lb. live weight: ground shelled corn 78.62, meat and bone scraps 6.40, soybean oil meal 12.70, vitamin-antibiotic-zinc premix 0.88, steamed bone meal 1.00, trace mineralized salt 0.40. From 120 lb. to market weight, ground shelled corn was increased to 83.19%, meat and bone scraps reduced to 4.30%, soybean oil meal lowered to 9.67%, and 0.56% limestone was added. The hogs were weighed off feed at 7:00 a.m., and given access to water until slaughtered the following morning.

Trial I was designed to study the development of hogs and the influence of sex upon growth. Trios of weanling littermate gilts, barrows, and boars were alloted to groups for slaughter at 100 lb., 150 lb. and 210 lb. (See table 1). Detailed carcass data included chilled carcass weight and length; backfat thickness; square inches of loin eye area at fifth rib, tenth rib and fourth lumbar vertebrae; weight of Longissimus dorsi muscle; % moisture in Longissimus dorsi; weight of each primal cut; weight of fat; weight of edible portion in each of the lean cuts; and, tenderness and flavor scores as determined by a taste panel. In Trial II, a comparison was made of

[1] Published with the approval of the Associate Director as Journal Article No. 10-60.

[2] Present address: International Milling Co., Des Moines, Iowa.

[3] The authors gratefully acknowledge the assistance of C. R. Weaver, Station Statistician, for his assistance with the statistical analysis.

TABLE 1. EXPERIMENTAL DESIGN SHOWING NUMBER OF HOGS IN EACH GROUP FOR TRIAL I [a]

Weight group [b]	100 lb.	150 lb.	210 lb.
Gilts	10	10	10
Barrows	10	10	10
Boars	5	5	4

[a] Repeated in Trial II with eight gilts and eight barrows slaughtered at 150 lb. and 210 lb.
[b] Litter mates were allotted to the nine lots.

gilts and barrows slaughtered at 150 and 210 lb. and of barrows receiving stilbestrol implants of 1.5, 3 and 6 mg. in the ear as each pig reached a weight of 150 lb. Slaughter and carcass data similar to those described in Trial I were obtained.

The last trial to be completed included six lots, each of 10 Durocs, treated as follows: control gilts, control barrows, three lots of barrows implanted subcutaneously in the ear at 150 lb. live weight with 1.5 mg., 3 mg. and 6 mg. of stilbestrol, respectively, and one lot of gilts implanted with 3 mg. of stilbestrol in the ear at 150 lb. live weight. Data on feed utilization, carcass length, backfat thickness, area of loin eye, and weights of primal cuts were obtained.

Results and Discussion

Carcass data obtained from the first trial are shown in table 2. Based on data from this trial, it would appear that the differences in leanness begin to show most obviously after the hogs reach 150 lb. At market weight of 210 lb., the data indicate that on the average gilts excel over their littermate barrows in the following respects: less backfat, heavier loin muscle, greater carcass length, and higher yield of lean cuts. This is in agreement with investigations using full sib barrow and gilt pairs reported by Bruner *et al.* (1958). Additionally, in this trial, boars outperformed littermate

TABLE 2. COMPARISON OF LITTERMATES BY SEX AND BY SLAUGHTER WEIGHT GROUP

	100 lb.			150 lb.			210 lb.		
Slaughter weight group	Gilts	Bar.	Boars	Gilts	Bar.	Boars	Gilts	Bar.	Boars
No. of animals	10	10	10	10	10	10	5	5	4
Dressing percentage	71.4	71.0	70.2	75.3	75.9	74.4	78.1	77.1	75.7
Carcass length, in.	24.3	24.2	24.4	27.0	26.7	27.0	29.2	28.3	29.4
Backfat thickness, in.	1.1	1.0	0.9	1.4	1.4	1.2	1.6	1.8	1.5
Longissimus dorsi, lb.[a]	1.5	1.4	1.5	2.2	2.1	2.3	2.9	2.2	3.0
Lean cuts, % [b]	40.3	39.8	40.6	39.3	39.3	40.3	39.5	36.2	40.2
Tenderness [c]	7.0	7.5	7.2	7.4	7.4	7.1	7.5	7.4	7.4
Flavor [d]	6.3	6.5	6.1	6.5	6.4	6.4	6.5	6.7	5.6

[a] Weight of muscle.
[b] Percent of kill weight.
[c] Scoring system: 10=very tender; 1=very tough.
[d] Scoring system: 9=like extremely; 1=dislike extremely.

barrows and gilts with respect to the same desirable traits mentioned above. Bratzler *et al.* (1954) published the results of barrow, late castrate, and boar carcass comparisons which showed that 180-lb. castrates and boars had less backfat and higher preferred cut yield. Similar performance of beef cattle was reported by Klosterman *et al.* (1954) who established the effectiveness of delayed castration to increase rate of gain and degree of muscling of Hereford males.

Within this relatively narrow age and weight range only slight differences in tenderness were noted. As boars reached 210 lb., the "sex associated" flavor was evident in some carcasses.

TABLE 3. STATISTICAL COMPARISON OF SEVERAL CHARACTERISTICS OF CARCASSES FROM LITTERMATE BARROWS AND GILTS AT TWO LEVELS OF DEVELOPMENT, 150 LB. AND 210 LB.

Variable	Number of observations		Mean differences[a]		Standard error		t	
	150	210	150	210	150	210	150	210
Carcass length, in.	17	20	0.247	0.210	0.131	0.222	1.885	0.947
Mean backfat, in.	17	20	0.018	—.032	.045	.051	0.401	—.623
Loin area—10th rib	18	20	0.028	0.531	.095	.097	0.292	5.486**
Mean loin area[b]	18	12	0.034	0.344	.073	.100	0.462	3.432**
Wt., long. dorsi	18	12	0.082	0.272	.051	.134	1.605	2.029
Lean cuts, %[c]	18	20	0.041	1.391	.300	.424	0.137	3.278**
Primal cuts, %[c]	18	20	—.182	1.359	.305	.407	—.598	3.336**
Fat, %[c]	18	20	0.208	—.928	.481	.804	0.433	—1.154

[a] Gilt data minus barrow data.
[b] Measured at 5th rib, 10th rib and 4th lumbar.
[c] Percent of kill weight.
** Significant at 0.01.

Further analysis of the gilt and barrow comparison was made. Data on all the control animals slaughtered at 150 and 210 lb. in this project were subjected to statistical analysis and are presented in table 3. These statistical tests support the discussion in the previous paragraph.

Results of Trials II and III which were concerned primarily with the influence of stilbestrol on growth and carcass characteristics are presented in tables 4 and 5. The figures in table 4 indicate that the implantation of stilbestrol in barrows tended to retard the rate of gain. Improved feed efficiency was associated with increasing level of stilbestrol in the spring but not in the fall trial. These results are in contrast with those reported by Dinusson *et al.* (1951) who found subcutaneous implantation of stilbestrol in swine improved feed efficiency, and the trial by Woehling *et al.* (1951) which showed no significant effect from stilbestrol and testosterone treatment. Seasonal influence was not mentioned in the 1951 reports cited.

Gilts which received a 3-mg. implant of stilbestrol gained more rapidly and consumed less feed per unit of gain than the gilts in the control lot. However, no significant differences were noted in the carcass data of the gilts.

TABLE 4. INFLUENCE OF IMPLANTING STILBESTROL[a] AT A WEIGHT OF 150 LB. ON GROWTH PERFORMANCE

Treatment	Gilts		Barrows			
			Stilbestrol			
	Control	Stil., 3 mg.	Control	1½ mg.	3 mg.	6 mg.
Trial II (1958, Spring)						
No. of pigs	8	...	8	8	7	8
Av. initial wt., lb.	138.0	...	139.2	137.6	136.4	138.1
Av. final wt., lb.	209.2	...	209.2	208.6	208.7	208.8
Av. daily gain, lb.	1.88	...	2.06	2.09	1.98	1.97
Feed per 100 lb. gain, lb.	360	...	360	353	350	345
Trial III (1958, Fall)						
No. of pigs	8	8	8	8	7	8
Av. initial wt., lb.	130.6	128.2	132.2	127.4	132.7	130.1
Av. final wt., lb.	207.4	208.4	208.6	208.4	208.9	206.4
Av. daily gain, lb.	1.78	1.90	2.19	1.97	2.09	2.06
Feed per 100 lb. gain, lb.	367	350	359	365	353	361

[a] Stilbestrol implanted in the ear as each pig reached a weight of 150 lb.

In table 5 are presented the carcass characteristics observed in the third trial. Loin eye size increased as the amount of stilbestrol was increased except for the 6-mg. dosage of Trial II. The percent primal cuts followed this same trend but the measurements of fat were not as consistent. These observations are somewhat similar to those of Pearson *et al.* (1952) who

TABLE 5. CARCASS TRAITS OF GILTS, BARROWS, AND BARROWS IMPLANTED[a] WITH STILBESTROL AT THREE LEVELS

Treatment	Gilts		Barrows			
			Stilbestrol			
	Control	Stil., 3 mg.	Control	1½ mg.	3 mg.	6 mg.
Trial II (1958, Spring)						
Carcass length, in.	29.8	..	30.0	29.7	29.3	29.3
Backfat thickness, in	1.53	..	1.57	1.65	1.57	1.55
Loin eye, sq. in.	3.96	..	3.65	3.71	3.90	3.73
Primal cuts, %[b]	51.1	..	50.2	49.5	51.3	50.6
Fat, %[b]	15.7	..	16.2	16.6	15.5	15.9
Moisture, %[c]	73.0	..	72.5	72.1	73.0	72.7
Trial III (1958, Fall)						
Carcass length, in.	29.3	29.2	29.1	28.9	29.3	29.0
Backfat thickness, in.	1.59	1.56	1.56	1.56	1.59	1.52
Loin eye, sq. in.	4.01	3.97	3.43	3.63	3.70	3.83
Primal cuts, %[b]	50.7	50.2	49.4	49.5	49.7	49.8
Fat, %[b]	16.5	16.3	17.2	17.2	16.7	17.2

[a] Implanted at 150 lb.
[b] Percent of kill weight.
[c] Percent of Longissimus dorsi muscle.

reported that stilbestrol implantation administered at much higher levels and at an earlier age had no effect on dressing percentage or thickness of backfat. Soft, watery condition of muscle frequently is attributed to stilbestrol treatment of the animal. Analysis of Longissimus dorsi muscle sample for total moisture revealed no significant differences due to sex or treatment.

From the results of these trials it may be concluded that growth performance and carcass development as influenced by alteration of normal hormonal function deserve further study. A worthy objective of future work would be the improvement of barrow carcasses to a point at least equal to that of littermate gilts. In addition, to improve palatability of meat from boars and to take advantage of the favorable muscle-fat ratio remains a challenge worthy of effort.

Summary and Conclusions

These trials have indicated that gilt carcasses tend to be leaner than barrow carcasses and that boar carcasses are leaner than either barrow or gilt carcasses. As the hogs grow beyond 150 lb., these differences become more pronounced. Stilbestrol ear implants of either 1.5 mg., 3 mg. or 6 mg. at 150 lb. had minor effects on growth rate and feed utilization. A positive trend existed between amount of stilbestrol implanted and both size of Longissimus dorsi and percent of primal cuts.

Literature Cited

Bratzler, L. J., R. P. Soule, Jr., E. P. Reineke and Pauline Paul. 1954. The effect of testosterone and castration on the growth and carcass characteristics of swine. J. Animal Sci. 13:171.

Bruner, W. H., V. R. Cahill, W. L. Robison and Richard F. Wilson. 1958. Performance of barrow and gilt littermate pairs at the Ohio Swine Evaluation Station. J. Animal Sci. 17:875.

Dinusson, W. E., Earle W. Klosterman and M. L. Buchanan. 1951. Stilbestrol effect of subcutaneous implantation on growing and fattening swine. J. Animal Sci. 10:885.

Klosterman, Earle W., L. E. Kunkle, Paul Gerlaugh and V. R. Cahill. 1954. The effect of age of castration upon rate and economy of gain and carcass quality of beef calves. J. Animal Sci. 13:817.

Pearson, A. M., G. E. Combs, Jr., H. D. Wallace, R. B. Sleeth, J. W. Stroud, J. M. Shepherd and Marvin Koger. 1952. The effects of stilbestrol implants on swine of different sexes. J. Animal Sci. 11:251.

Woehling, H. L., George D. Wilson, R. H. Grummer, R. W. Bray and L. E. Casida. 1951. Effects of stilbestrol and testosterone pellets implanted into growing-fattening pigs. J. Animal Sci. 10:889.

DIETHYLSTILBESTROL, OXYTETRACYCLINE, LINSEED OIL MEAL, SOYBEAN OIL MEAL AND LEVELS OF CORN SILAGE IN CATTLE FATTENING RATIONS[1, 2, 3]

O. E. Kolari, A. L. Harvey, J. C. Meiske, W. J. Aunan and L. E. Hanson

University of Minnesota, St. Paul

THE favorable effect of feeding diethylstilbestrol to fattening steers upon rate of gain and efficiency of feed use is well recognized. Results of several trials, however, indicate that fattening heifers show a smaller response to diethylstilbestrol than steers (Burroughs, *et al.*, 1955; Smith *et al.*, 1958b). Results of cattle feeding trials with antibiotics or a combination of a hormone-like compound and antibiotic have been variable suggesting a need for additional studies.

A two-phase system of feeding beef cattle in dry lot is often used. In this method of feeding, corn silage (or other forage) is fed in relatively high amounts during the first phase of feeding. High-energy rations are fed during the final, or second, phase of feeding. Recent data on the effect of feeding various levels of corn silage during the first phase upon the performance of the cattle during the entire feeding period are limited. Likewise, recent data on the comparative value of soybean oil meal and linseed oil meal in cattle feeding are limited.

The objectives of the present experiments with fattening cattle fed in dry lot were to compare: (1) diethylstilbestrol and oxytetracycline alone and in combination; (2) soybean oil meal and linseed oil meal at equal levels of crude protein intake; (3) different levels of corn silage fed during the high-forage phase of feeding upon the average performance of cattle during the entire feeding period; (4) response to treatments of steers and heifers.

Experimental Procedure

Sixty-four good-to-choice grade Herefords of western origin were randomly allotted on a weight and feeder grade basis into eight lots of eight cattle in each of four trials. The cattle were hand-fed twice daily. Water, trace mineralized salt and a mineral mixture (2 parts steamed bone meal to 1 part stock salt) were available at all times. The cattle were weighed "on" and "off" trial after an overnight shrink without feed or water and were routinely weighed at 28-day intervals. U.S.D.A. carcass grades were obtained from ribbed carcasses within a few days after final weights were

[1] Paper No. 4345, Scientific Journal Series of the Minnesota Agricultural Experiment Station.

[2] Acknowledgement is due Charles Pfizer & Co., Inc. for partial financial support and supplies of oxytetracycline, and Eli Lilly and Co. for diethylstilbestrol.

[3] The authors are indebted to Dr. C. E. Gates, Univ. of Minn., for statistical advice.

taken. The cattle were housed in a pole-type barn with access to outdoor lots.

Trial I. Eight lots, each of eight steers, were randomly assigned, two per treatment, into four treatment groups: (1) control; (2) 10 mg. stilbestrol fed daily; (3) 80 mg. oxytetracycline fed daily; and, (4) 10 mg. stilbestrol and 80 mg. oxytetracycline fed daily. Soybean oil meal was fed as the protein supplement to one lot of steers in each treatment group; linseed oil meal was fed to the other lot. Each protein supplement (solvent process) was fed to supply 0.5 lb. of crude protein per head daily. During the first 56 days on feed the steers were full-fed corn silage. Ear corn and hay were restricted to 9 and 2 lb. per head daily, respectively. Ground ear corn was full-fed the final 56 days on feed and corn silage and hay were restricted to 5 and 2 lb. per head daily, respectively.

Trial II. Treatments and allotting were similar to Trial I except that heifers were used and oxytetracycline was fed at 70 mg. per head daily. The fattening ration consisted of ground ear corn, full-fed; alfalfa-brome hay, 4 lb.; supplemental protein, expressed as crude protein, 0.5 lb.

Trial III. Eight lots, each of eight steers, were randomly assigned, two per treatment, to four groups. Corn silage was fed during the high-forage phase to the four treatment groups at four levels: (1) no silage; (2) full-fed silage; (3) ⅓ silage; (4) ⅔ silage. During the high-forage phase of 82 days (phase 1) the "full-fed" silage group was fed corn silage according to appetite, 6 lb. of ground ear corn and 4 lb. of alfalfa-brome hay per head daily. The "⅔ silage" and "⅓ silage" groups were fed ⅔ and ⅓, respectively, of the silage fed to the "full-fed silage" group. The "no silage" group was fed 4 lb. of alfalfa-brome hay per head daily as the only roughage. Ground ear corn was fed according to appetite to all groups except the "full-fed" silage group. Linseed oil meal was fed at 1.5 lb. per head daily to the "no silage" group. The linseed oil meal intake of the silage fed steers was adjusted so that the total daily crude protein intake was similar for all groups.

During the high-energy phase (57 days, phase 2) the silage-fed steers received 6 lb. of corn silage and 2 lb. of alfalfa-brome hay per head daily. The "no silage" group was fed 4 lb. of alfalfa-brome hay per head daily. All groups were fed 1.5 lb. of linseed oil meal per head daily and ground ear corn according to appetite.

Stilbestrol was fed at 10 mg. per head daily to all steers throughout the trial. Oxytetracycline was fed at 80 mg. per head daily to one lot of steers in each of the four treatment groups.

Trial IV. Treatments and allotting were similar to Trial III except that heifers were used, oxytetracycline was fed at 70 mg. per head daily and phases 1 and 2 of the trial were 140 and 67 days duration, respectively.

Results and Discussion

Average weight gains, daily rations, feed per unit weight gain and carcass data are shown in tables 1, 2, 3 and 4. Data on the combined average daily

TABLE 1. THE EFFECT OF DIETHYLSTILBESTROL, OXYTETRACYCLINE, LINSEED OIL MEAL AND SOYBEAN OIL MEAL ON PERFORMANCE OF FATTENING STEERS. NOVEMBER 14, 1956–MARCH 6, 1957 (112 DAYS). TRIAL I

Lot no.	7, 8	9, 10	11, 12	13, 14	7, 9, 11, 13	8, 10, 12, 14
Treatment	Control	Oxytetra-cycline	Diethyl-stilbestrol	Oxytetra-cycline +diethyl-stilbestrol	Soybean oil meal	Linseed oil meal
No. of steers	16	16	16	16	32	32
Initial wt., lb.	773	774	774	772	774	773
Final wt., lb.	1009	1041	1043	1068	1034	1046
Av. daily gain, lb.	2.11	2.38*	2.40*	2.64**	2.33	2.44
Change, %	....	+12.8	+13.7	+25.1	....	+4.7
Av. daily feed, lb.						
Ground ear corn	14.44	14.52	15.02	15.11	14.47	15.08
Protein supplement	1.26	1.26	1.26	1.25	1.09	1.42
Corn silage	19.46	21.43	21.54	21.44	20.89	21.03
Alfalfa-brome hay	2.14	2.14	2.13	2.13	2.14	2.14
Change, % [a]	....	+3.0	+5.2	+5.4	....	+4.0
Feed per cwt. gain, lb.						
Ground ear corn	686	610	626	572	622	619
Protein supplement	60	53	53	47	47	58
Corn silage [a]	308	300	299	271	299	288
Alfalfa-brome hay	102	90	89	81	92	88
Change, % [a]	...	—8.9	—7.7	—16.0	...	—0.7
Carcass grade [b]	8.4	8.6	8.0	8.4	8.1	8.6
Dressing percent	59.0	58.1	57.2	58.4	57.6	58.8

[a] Three lb. silage converted to 1 lb. dry feed.
[b] Carcass grades: 8, good; 9, high good.
* $P<.05$ (L.S.D.=0.24).
** $P<.01$ (L.S.D.=0.32).

TABLE 2. THE EFFECT OF DIETHYLSTILBESTROL, OXYTETRACYCLINE, LINSEED OIL MEAL AND SOYBEAN OIL MEAL ON PERFORMANCE OF FATTENING HEIFERS. MARCH 27, 1957–SEPTEMBER 25, 1957 (182 DAYS). TRIAL II

Lot no.	21, 22	23, 24	25, 26	27, 28	21, 23, 25, 27	22, 24, 26, 28
Treatment	Control	Oxytetra-cycline	Diethyl-stilbestrol	Oxytetra-cycline +diethyl-stilbestrol	Soybean oil meal	Linseed oil meal
No. of heifers [a]	16	16	15	15	30	32
Initial wt., lb.	531	531	528	525	527	531
Final wt., lb.	926	944	966	976	940	965
Av. daily gain, lb.*	2.17	2.27	2.40**	2.48**	2.27	2.39
Change, %	....	+4.6	+10.6	+14.3	....	+5.3
Av. daily feed, lb.						
Ground ear corn	16.02	15.37	14.75	14.82	15.22	15.29
Protein supplement	1.32	1.31	1.23	1.23	1.10	1.44
Alfalfa-brome hay	3.91	3.85	3.59	3.60	3.75	3.73
Change, %	....	—3.4	—7.9	—7.5	—1.9	....
Feed per cwt. gain, lb.						
Ground ear corn	738	677	614	599	673	641
Protein supplement	61	58	51	50	49	60
Alfalfa-brome hay	180	170	150	145	166	156
Change, %	...	—7.6	—16.8	—18.9	...	—3.5
Carcass grade [b]	10.4	10.0	9.5	10.5	10.2	10.0
Dressing percent	60.6	60.9	59.4	59.8	60.2	60.2

[a] One heifer removed from lots 25 and 27 because of prolapses.
[b] Carcass grades: 9, high good; 10, low choice; 11, choice.
* $P<.05$ (L.S.D.=0.17).
** $P<.01$ (L.S.D.=0.23).

TABLE 3. THE EFFECT OF DIETHYLSTILBESTROL, OXYTETRACYCLINE AND LEVELS OF CORN SILAGE ON PERFORMANCE OF FATTENING STEERS. OCTOBER 2, 1957–FEBRUARY 18, 1958 (139 DAYS). TRIAL III

Lot no.	1, 2	3, 4	5, 6	7, 8	1, 3, 5, 7	2, 4, 6, 8
Treatment[a]	No silage	⅓ silage	⅔ silage	Full-fed silage	Diethyl-stilbestrol	Diethylstil-bestrol+oxy-tetracycline
No. of steers[b]	16	15	16	16	31	32
Initial wt., lb.	784	786	784	784	785	784
Final wt., lb.	1136	1143	1121	1103	1124	1127
Av. daily gain, lb.	2.53	2.57	2.42	2.29	2.44	2.46
Change, %	+10.5	+12.2	+5.7	....	....	....
Av. daily feed, lb.						
Ground ear corn	20.20	17.67	15.97	11.64	16.28	16.41
Protein supplement	1.48	1.59	1.55	1.71	1.58	1.58
Corn silage	....	8.45	14.80	21.19	11.50	10.81
Alfalfa-broome hay	4.22	3.42	3.32	3.26	3.56	3.56
Change, %[c]	+9.4	+7.7	+8.9	....	....	—0.4
Feed per cwt. gain, lb.						
Ground ear corn	798	688	659	507	667	666
Protein supplement	58	62	64	74	65	64
Corn silage[c]	...	110	204	308	157	146
Alfalfa-brome hay	167	133	137	142	146	144
Change, %[c]	—0.8	—3.7	+3.2	...	...	—1.5
Carcass grade[d]	9.9*	9.9*	10.2*	9.0	9.6	9.9
Dressing percent	60.0	59.6	60.0	58.4	59.3	59.7

[a] Given silage levels fed only first 82 days; 6 lb. silage per head daily fed to all silage lots last 57 days.
[b] One steer removed from lot 3 because of illness.
[c] Three lb. corn silage converted to 1 lb. dry feed.
[d] Carcass grades: 9, high good; 10, low choice; 11, choice.
* $P<.05$ (L.S.D.=0.77).

gains and carcass grades of Trials I and II are presented in table 5. Similar data for Trials III and IV are in table 6.

Oxytetracycline fed at 80 mg. per head daily to fattening steers increased weight gains significantly ($P<.05$) from 2.11 to 2.38 lb. per head daily in Trial I (table 1). It increased weight gains of fattening heifers but not significantly (4.6%) in Trial II (table 2). When these data were combined for analysis of variance, the increased gains proved to be significant ($P<.01$, table 5). In contrast, weight gains were not significantly increased by feeding oxytetracycline in Trials III and IV (tables 3 and 4). Beeson and Perry (1958) have reported similar data. However, stimulation of weight gains of fattening cattle as a result of feeding oxytetracycline (Dyer *et al.*, 1957; Thomas, 1958; Sherman *et al.*, 1959) has been reported and is in agreement with Trials I and II.

Feed per unit gain was reduced when oxytetracycline was fed alone or in combination with diethylstilbestrol in all four trials. Similar results have been reported by Beeson *et al.* (1957) and Dyer *et al.* (1957). Carcass grades were not affected significantly by feeding oxytetracycline in Trials I and II. The differences in the carcass grades of the cattle fed stilbestrol or stilbestrol and oxytetracycline (Trials III and IV) were not statistically significant when the data from the trials were analyzed separately. How-

TABLE 4. THE EFFECT OF DIETHYLSTILBESTROL, OXYTETRACYCLINE AND LEVELS OF CORN SILAGE ON PERFORMANCE OF FATTENING HEIFERS. MARCH 5, 1958–SEPTEMBER 28, 1958 (207 DAYS). TRIAL IV

Lot no.	15, 16	17, 18	19, 20	21, 22	15, 17, 19, 21	16, 18, 20, 22
Treatment[a]	No silage	⅓ silage	⅔ silage	Full-fed silage	Diethyl-stilbestrol	Diethylstil-bestrol+oxy-tetracycline
No. of heifers	16	16	16	16	32	32
Initial wt., lb.	521	521	521	521	521	521
Final wt., lb.	973	969	952	942	955	963
Av. daily gain, lb.	2.18	2.16	2.08	2.03	2.09	2.13
Change, %	+7.4	+6.4	+2.5	....	....	+1.9
Av. daily feed, lb.						
Ground ear corn	14.84	13.33	11.56	9.36	12.38	12.17
Protein supplement	1.48	1.63	1.87	2.05	1.76	1.76
Corn silage	....	5.40	9.40	13.27	7.01	7.02
Alfalfa-brome hay	3.84	3.30	3.26	3.33	3.44	3.43
Change, %[b]	+5.2	+4.7	+3.4	....	....	—1.1
Feed per cwt. gain, lb.						
Ground ear corn	681	617	556	460	591	571
Protein supplement	68	75	90	101	84	82
Corn silage[b]	...	83	151	217	112	110
Alfalfa-brome hay	176	153	157	164	164	161
Change, %[b]	—1.8	—1.5	+1.3	...	...	—2.8
Carcass grade[c]	10.4	10.2	9.9	9.4	9.7	10.2
Dressing percent	60.8	60.1	60.6	60.0	60.3	60.4

[a] Given silage levels fed only first 140 days; 6 lb. silage per head daily fed to all silage lots last 67 days.
[b] Three lb. corn silage converted to 1 lb. dry feed.
[c] Carcass grades: 9, high good; 10, low choice; 11, choice.

ever, when the data were combined the carcass grade (10.1) of the cattle fed stilbestrol in combination with oxytetracycline was significantly higher ($P<.05$) than that (9.7) of the cattle fed stilbestrol.

Daily weight gains were increased significantly, 13.7% (steers) and 10.6% (heifers), over the controls as a result of feeding diethylstilbestrol. When the weight gain data from these two trials were combined and analyzed statistically, the increased gain from diethylstilbestrol was highly significant (table 5, $P<.01$). Diethylstilbestrol reduced the amount of feed required per unit gain by 7.7% and 16.8% for steers and heifers, respectively (tables 1 and 2).

The carcass grades of the steers and heifers fed diethylstilbestrol, alone, were lower than those of the other treatment groups (tables 1 and 2). These differences were not statistically significant. Bohman *et al.* (1957)

TABLE 5. COMBINED AVERAGE DAILY GAINS AND CARCASS GRADES IN TRIALS I AND II

Treatment[a]	Control	OTC	DES	OTC+DES
Av. daily gain, lb.	2.14	2.33**	2.40**	2.56**
Carcass grade[b]	9.4	9.3	8.8	9.4

[a] OTC=oxytetracycline; DES=diethylstilbestrol.
[b] Carcass grade: 8, good; 9, high good; 10, low choice.
** $P<.01$.

and Clegg and Carroll (1957) have reported similar results. Other experimental evidence suggests that diethylstilbestrol has no consistent effect on carcass grade (Aunan *et al.*, 1959; Kastelic *et al.*, 1956; O'Mary *et al.*, 1959) when the animals are fed for the same length of time.

A combination of diethylstilbestrol and oxytetracycline stimulated weight gain 25.1% and 14.3% over the controls in Trials I and II, respectively. Their effect was additive. Numerous reports have indicated a similar additive effect resulting from the feeding of a combination of an antibiotic and a synthetic hormone-like compound (Dyer *et al.*, 1957; Parsons *et al.*, 1958; Thomas *et al.*, 1958; Sherman *et al.*, 1959). However, results of Trials III and IV indicated that the combination was only slightly superior to diethylstilbestrol alone, when weight gains and efficiency of feed use were the criteria.

TABLE 6. COMBINED AVERAGE DAILY GAINS AND CARCASS GRADES IN TRIALS III AND IV

Treatment	No silage	⅓ silage	⅔ silage	Full-fed silage
Av. daily gain, lb.	2.36	2.37	2.25	2.16
Carcass grade*	10.2**	10.1**	10.0**	9.2

* Carcass grade: 9, high good; 10, low choice.
** $P<.01$ (L.S.D.$=0.68$).

The effect of the feed additive on daily feed intake was variable. Oxytetracycline and/or diethylstilbestrol appeared to increase feed intake in Trial I and to decrease it in Trial II. Some other experimental results show a stimulation of daily feed intake by feeding diethylstilbestrol (Burroughs *et al.*, 1955; Clegg and Carroll 1957; Perry *et al.*, 1958), and other data do not (Bohman *et al.*, 1957; O'Mary *et al.*, 1959). Beeson and Perry (1958) and Sherman *et al.* (1959) reported an increase in daily feed intake of fattening steers when oxytetracycline was fed; Bohman *et al.* (1957) reported a decrease when an antibiotic was fed.

Average daily weight gains of cattle fed soybean oil meal and linseed oil meal were, respectively, 2.33 and 2.44 lb. in Trial I, and 2.27 and 2.39 lb. in Trial II. Differences were not statistically significant when the data from the trials were analyzed separately. When the data were combined, daily gains of cattle fed linseed oil meal (2.41 lb.) were significantly ($P<.05$) greater than those of cattle fed soybean oil meal (2.30 lb.). Recent reports have indicated little difference in the feeding value of the two protein supplements (Matsushima *et al.*, 1956; Smith *et al.*, 1958a; Webb *et al.*, 1958). No difference was observed in hair coat "bloom" of the cattle fed either linseed or soybean oil meal. Carcass grades were not significantly affected by the protein source.

Average daily weight gains of the "no silage", "⅓ silage", "⅔ silage" and "full-fed silage" groups were, respectively, 2.53, 2.57, 2.42 and 2.29 lb.

in Trial III, and 2.18, 2.16, 2.08 and 2.03 lb. in Trial IV. Differences were not statistically significant. The "full-fed silage" group had the lowest carcass grade ($P<.01$). Had these cattle been fed for a longer time the carcass grade of this group undoubtedly would have been higher. Carcass grades among the other silage groups were similar.

If it is assumed that 3 lb. of corn silage is equivalent to 1 lb. of air-dry feed, the "full-fed silage" group ate the least amount of air-dry feed (Trials III and IV). This may partially explain why the cattle "full-fed silage" made the lowest average weight gain and carcass grade. Efficiency of feed use was quite similar for the various silage groups.

In contrast to the results reported in this paper, Klosterman *et al.* (1958a) reported little difference in the performance of fattening steers fed three levels of corn silage. However, in another trial, and in agreement with Trials III and IV, Klosterman *et al.* (1958b) reported that heifers full-fed ground ear corn gained significantly faster and produced higher grading carcasses than heifers full-fed corn silage with limited ear corn.

Summary

Results of four trials are reported in which diethylstilbestrol and oxytetracycline (alone or in combination), linseed oil meal, soybean oil meal and various levels of corn silage were fed to fattening cattle.

Average daily gains were increased significantly and less feed per unit gain was required when diethylstilbestrol and a combination of diethylstilbestrol and oxytetracycline were fed in two trials. Oxytetracycline increased daily weight gains significantly in one trial and slightly in three other trials. It improved efficiency of feed use. Cattle fed linseed oil meal gained 5% more rapidly than cattle fed soybean oil meal. Cattle "full-fed" silage during the high-forage phase of feeding had significantly lower carcass grades than cattle fed lesser amounts of silage.

Literature Cited

Aunan, W. J., A. L. Harvey and O. E. Kolari. 1959. Effect of stilbestrol on carcass quality. Minnesota Beef-Grassland Field Day Report B–22.

Beeson, W. M., T. W. Perry, M. Mohler, F. N. Andrews and M. Stob. 1957. Combination of an antibiotic and a female hormone for fattening steers. J. Animal Sci. 16:845.

Beeson, W. M. and T. W. Perry. 1958. The comparative feeding value of high moisture corn and low moisture corn with different feed additives for fattening beef cattle. J. Animal Sci. 17:368.

Bohman, V. R., M. A. Wade and J. E. Hunter. 1957. The effect of chlortetracycline, stilbestrol and animal fat on fattening steers. J. Animal Sci. 16:833.

Burroughs, W., C. C. Culbertson, E. Cheng, W. H. Hale and P. Homeyer. 1955. The influence of oral administration of diethylstilbestrol to beef cattle. J. Animal Sci. 14:1015.

Clegg, M. T. and F. D. Carroll. 1957. A comparison of the method of administration of stilbestrol on growth and carcass characteristics of beef steers. J. Animal Sci. 16:662.

Dyer, I. A., M. E. Ensminger and R. L. Blue. 1957. Effects of fat, oxytetracycline and stilbestrol on performance and hepatic stores of carotene and vitamin A in steers. J. Animal Sci. 16:828.

Kastelic, J., P. Homeyer and E. A. Kline. 1956. The influence of the oral administration of diethylstilbestrol on certain carcass characteristics of beef cattle. J. Animal Sci. 15:689.

Klosterman, E. W., A. L. Moxon and L. E. Kunkle. 1958a. Levels of corn silage and protein in rations for fattening steers. Ohio Agr. Exp. Stat. Mimeo. Rept., Beef Cattle Research.

Klosterman, E. W., W. L. Roller, N. B. King and V. R. Cahill. 1958b. A comparison of housing, the implantation of stilbestrol and a combination of stilbestrol and testosterone in fattening heifers with and without corn silage in the ration. Ohio Agr. Exp. Stat. Mimeo. Rept., Beef Cattle Research.

Matsushima, J., T. W. Dowe and V. H. Arthaud. 1956. Cattle fattening. I. When should stilbestrol be added during the fattening period? II. Is stilbestrol more effective with a certain protein supplement? Neb. Agr. Exp. Stat. Mimeo. Rept. 233.

O'Mary, C. C., A. E. Cullison and J. L. Carmon. 1959. Implanted and oral stilbestrol for fattening steers. J. Animal Sci. 18:14.

Parsons, A. R., F. H. Baker and W. P. Garrigus. 1958. The effect of terramycin and diethylstilbestrol additions on fattening steers being fed an economy supplement. Ky. Agr. Exp. Stat. Annual Livestock Field Day.

Perry, T. W., W. M. Beeson, F. N. Andrews, M. Stob and M. T. Mohler. 1958. The comparative effectiveness of oral and subcutaneous implantation of diethylstilbestrol in combination with chlortetracycline. J. Animal Sci. 17:164.

Sherman, W. C., W. H. Hale, W. M. Reynolds and H. G. Luther. 1959. The effect of tranquilizers, diethylstilbestrol and oxytetracycline alone and in combination on performance of steers. J. Animal Sci. 18:198.

Smith, E. F., B. A. Koch, F. W. Boren and G. L. Walker. 1958a. A comparison of the amount and kind of protein concentrate for yearling steers on blue stem pasture. Kans. Agr. Exp. Stat. Circ. 358.

Smith, E. F., D. Richardson, B. A. Koch, R. A. Merkel and F. W. Boren. 1958b. The effect of feeding stilbestrol to open and spayed heifers. Kans. Agr. Exp. Stat. Circ. 358.

Thomas, O. O. 1958. Dynafac, stilbestrol and terramycin in the rations for weaned calves. Mont. Agr. Exp. Stat. A.I. Leaflet 12.

Webb, R. J., C. F. Cmarik and A. L. Neumann. 1958. Comparison of soybean meal, linseed meal and cottonseed meal when fed singly or in combination to fattening steers. Ill. Agr. Exp. Stat. Mimeo. Rept. DS 40–324.

EFFECT OF ENERGY LEVEL ON THE PROTEIN REQUIREMENT OF LAMBS FATTENED WITH AND WITHOUT STILBESTROL

J. R. Jones and D. E. Hogue

Cornell University, Ithaca, New York

NUMEROUS lamb feeding trials have shown stilbestrol to increase gains and feed efficiency since the first report by Andrews *et al.* (1949).

Interest in protein and energy levels increased after interactions were shown. Bosshardt *et al.* (1946) compared caloric intake with protein utilization in growing albino rats; at a given level of protein intake, changes in caloric intake often resulted in changes in the apparent utilization of protein. Donaldson *et al.* (1955) showed that the energy to protein ratio in the diet of chickens influenced the caloric intake, feed efficiency, and growth rate; and, Hill *et al.* (1956) concluded that the energy intake of growing chicks is governed mainly by dietary energy concentration and to a lesser extent by protein level. In 1951 Lofgreen *et al.*, working with young dairy calves, found that the efficiency of utilization of protein in high protein rations, as measured by nitrogen balance is markedly affected by energy intake.

Recently, attention has been directed to the possible interactions of stilbestrol and various dietary factors. Hartman *et al.* (1958) obtained a greater stilbestrol response with a high roughage ration than with a high concentrate ration fed to lambs. Preston and Burroughs (1958) reported that the combined influence of protein and energy alters the effect of stilbestrol on the degree of fatness of lamb carcasses. They suggested that additional carcass fatness might be obtained by adding stilbestrol to a ration with a wide calorie to protein ratio; and additional leanness by adding it to a ration with a relatively narrow calorie to protein ratio.

The purpose of this feeding trial was to evaluate further the response of lambs fed different levels of protein and energy with and without stilbestrol in search of a consistent trend of treatment effects and interrelationships.

Experimental Procedure

A feed-lot trial of 98 days duration was begun the middle of October 1957 (Jones *et al.*, 1958). One hundred ninety-two western white-faced wethers of one-half to three-fourths fine wool breeding, averaging 70 lb., were randomly divided into 16 groups of 12 lambs each, but balanced according to initial weight by a weight group stratification procedure. The lambs were weighed biweekly and live weight grades were determined at the end of the experiment.

The 2^3 factorial arrangement of treatments utilized eight treatment groups with each group duplicated, placing 24 lambs on each treatment.

The variables included two levels each of estimated net energy and estimated digestible protein fed with (S) and without (NS) oral stilbestrol. The estimated net energy and protein levels were set at 90 and 120% of the minimal recommendations according to Morrison (1957). The 90% levels of energy and protein were designated the low levels (LE and LP, respectively), and the 120% levels were designated the high levels (HE and HP, respectively).

Mixed U. S. No. 3 green alfalfa and heavy timothy hay (second cutting) and well-matured corn silage constituted the roughage part of the ration. The roughage to concentrate ratio, kept constant within each treatment, was 61:39 for the low energy treatments and 51:49 for the high energy treatments. Number 2 yellow shelled corn and soybean oil meal were fed in such combinations as to give the desired energy and protein level for each treatment group. Ration levels were adjusted weekly to the nearest 5-lb. weight average for each particular lot. (As an example, the maximal daily ration for an 80-lb. lamb in a HE–HP group was, 0.5 lb. hay, 3.0 lb. silage, 1.3 lb. corn and 0.18 lb. soybean oil meal). The lambs were full-fed up to the appropriate prescribed maximal amount. Table 2 indicates the percentage of expected or prescribed maximum of ENE consumed by each group.

During the first half of the trial, stilbestrol was fed at the rate of 5 mg. per lamb per day. During the second half, stilbestrol was reduced to 2.5 mg. per lamb per day, a procedure used by Davey and Wellington (1959). The stilbestrol was mixed with ground corn, such that one pound of the mixture would supply the correct amount of stilbestrol for one lot for one day. All lots received one pound of ground corn per day regardless of whether they received stilbestrol or not. Both iodized salt and water were available at all times. All feed refusals were weighed and sampled. Proximate analyses were made on all ration ingredients and feed refusals.

Early in the trial two lambs were lost with enterotoxemia, one from the LE–HP group and one from the LE–LP group. Approximately half way through the trial, four lambs receiving stilbestrol were lost because of urinary calculi, two on the LE–LP, one on the LE–HP, and one on the HE–LP treatment. Two lambs from the HE–LP group receiving stilbestrol gained less than 10 lb. for the 98-day period; their data were not used. Thus, eight lambs from the several groups were removed from the trial. To correct the data for these groups the average value of the appropriate treatment group was used as an estimate of the missing observation for that group.

Data were analyzed statistically by the analysis of variance technique for a 2^3 factorial arrangement of treatments as presented by Snedecor (1956).

Results and Discussion

Chemical analyses and estimated net energy and digestible protein of the feeds are shown in table 1. Average nutrient consumption of the lambs

TABLE 1. CHEMICAL ANALYSES AND ESTIMATED NET ENERGY AND DIGESTIBLE PROTEIN OF THE FEEDS[a]

Ration ingredients	Alfalfa hay[b]	Corn silage	Corn	S.B.O.M.
Dry matter, %	88.9	27.7	85.4	88.0
Crude fiber, %	29.5	6.0	2.7	7.2
Crude protein, %	11.9	3.2	8.3	44.6
Ether extract, %	2.5	6.2	2.9	1.3
Ash, %	5.4	1.2	1.1	4.8
N.F.E., %	44.2	12.2	72.0	36.3
ENE, therms/cwt.[c]	45.0	16.2	80.1	79.6
Estimated dig. protein, %	8.4	1.7	6.4	41.0

[a] Presented on an as-fed basis.
[b] U. S. No. 3 green alfalfa heavy timothy mixed hay. (64.6% alfalfa, 32.1% timothy, 3.3% clover).
[c] Morrison, F. B. (1957) Feeds and Feeding (22nd ed.).

is shown in table 2 and average daily gain, average liveweight grade and feed efficiency in table 3. Table 4 shows mean squares from the analyses of variance on weight gains, liveweight grades and feed efficiency.

Protein. Differences in both average daily gain and liveweight grade as well as feed efficiency were detected ($P<0.01$) between protein levels. The average digestible protein (dry-matter basis) of the high level was 11.2% vs. 8.4% for the low level. The high level produced an average daily gain of 0.34 lb. and a weight grade score of 6.0, and the low protein level produced an average daily gain of 0.28 lb. and a liveweight grade score of 5.4. Consumption was increased at the higher protein level.

Energy. Differences in liveweight gain or grade between the energy levels were not statistically significant. Average daily gain and liveweight grade scores were 0.32 lb. and 5.8, respectively for the high energy level and

TABLE 2. AVERAGE NUTRIENT CONSUMPTION OF FATTENING LAMBS AS AFFECTED BY STILBESTROL, PROTEIN AND ENERGY

		HE		LE		
Treatments		HP	LP	HP	LP	Av.
D.M. consumed	S	2.26	1.99	1.99	1.93	2.03
(lb./lamb/day)	NS	2.26	2.00	1.99	1.89	2.04
	Av.	2.26	2.00	1.99	1.91	....
Est. dig. protein	S	0.23	0.15	0.25	0.18	0.20
consumed (lb./lamb/day)	NS	0.23	0.15	0.25	0.18	0.20
ENE consumed	S	1.73	1.50	1.43	1.40	1.51
(therms/lamb/day)	NS	1.73	1.52	1.42	1.37	1.51
ENE consumed	S	90.0	78.1	99.0	97.2	91.1
(% of expected)	NS	90.1	79.0	98.8	95.3	90.8
	Av.	90.0	78.6	98.9	96.2	....
Iodized salt	S	3.2	3.4	3.0	3.1	3.2
consumed (lb./lamb)	NS	2.4	2.3	3.0	3.0	2.7

TABLE 3. DAILY GAIN, LIVEWEIGHT GRADE AND FEED EFFICIENCY OF FATTENING LAMBS AS AFFECTED BY STILBESTROL, ENERGY AND PROTEIN

Treatments		HE		LE		Av.
		HP	LP	HP	LP	
Av. initial wt., lb.	S	71.7	71.5	67.2	69.0	69.9
	NS	71.5	70.9	67.2	69.1	69.7
Av. daily gain, lb.	S	0.38	0.30	0.35	0.34	0.34
	NS	0.35	0.24	0.30	0.26	0.29
	Av.	0.36	0.27	0.32	0.30	....
Av. final liveweight grade[a]	S	5.9	5.0	5.3	5.1	5.3
	NS	6.8	5.5	5.8	5.9	6.0
	Av.	6.4	5.3	5.6	5.5	...
Efficiency (therms ENE/lb. gain)	S	4.54	5.11	4.13	4.17	4.49
	NS	5.01	6.27	5.02	5.36	5.42
	Av.	4.78	5.69	4.58	4.76	....

[a] Choice=8, good=6, utility=4.

0.31 lb. and 5.5, respectively, for the low. Within each protein level a difference between responses to energy levels actually existed but this difference was in a different direction within each protein level. An increase in energy in the high protein treatment resulted in an increase in response whereas in the low protein treatment it produced a decrease.

Protein and Energy. The interactions between protein and energy on average daily gain, liveweight grade and feed efficiency were significant ($P<0.01$). The HE–HP groups gained faster and graded higher than other treatment groups, but the LE–HP groups were the most efficient (table 3). The HE–LP groups gained slower, were the least efficient and graded lower than the other treatment groups. The estimated net energy

TABLE 4. MEAN SQUARES FROM THE ANALYSES OF VARIANCE ON LIVEWEIGHT GAIN, GRADE AND FEED EFFICIENCY

Source of variation	d.f.	Total liveweight gain	Final liveweight grade	Feed efficiency[b]
Stilbestrol	1	1333.5[a]	22.3[a]	3.28[a]
Energy	1	27.0	3.8	1.30[a]
Protein	1	1704.3[a]	16.8[a]	1.32[a]
Stil. x Energy	1	50.0	0.1	0.06
Stil. x Protein	1	58.3	0.1	0.25[a]
Energy x Protein	1	601.9	12.7[a]	0.58[a]
Stil. x Energy x Protein	1	6.2	1.7	0.00
Residual	166	40.7	1.1	0.036 (8 d.f.)[c]

[a] Significant ($P<0.01$).
[b] Therms ENE/lb. gain.
[c] Analyzed on a lot-average basis.

intake figures expressed as percentages of expected or desired consumption (table 2) show that all groups with the exception of the HE–LP group consumed 90% or more of the expected amounts. The HE–LP group consumed only 78.6% of the expected amount of estimated net energy. The LE–HP group gave the highest percentages of expected consumption. It appears that as the energy level is increased, it is also necessary to increase the protein level to maintain feed consumption and growth rate of the animals. It is not possible to establish a quantitative relationship on the basis of this experiment.

The protein and energy interrelationships shown here are in accord with those reported in work with other species (Bosshardt *et al.*, 1946; Lofgreen *et al.*, 1951; Donaldson *et al.*, 1955; Hill *et al.*, 1956). The low performance of animals fed the HE–LP diets, as was shown in this trial, has been discussed by other workers. Meyer (1958) reported that a low protein intake in relation to energy influences food intake indirectly through the apparently adverse ratio of the two nutrients. Meyer (1958) also states that as the energy portion of the diet is decreased food intake increases because the animal no longer needs to dispose of the excess energy as body fat or heat.

Stilbestrol. The addition of stilbestrol increased ($P<0.01$) average daily gain and feed efficiency and decreased ($P<0.01$) liveweight grade (table 3). Percentage increases due to stilbestrol both in feed efficiency and total gain were greatest for the LE–LP group, intermediate for the LE–HP and HE–LP groups, and least for the HE–HP group. Average results from high and low roughage rations showed that stilbestrol had the greater beneficial effects on gain and feed efficiency with high roughage rations; these were the low energy rations. This finding is in agreement with the work of Hartman *et al.* (1958).

Liveweight grade was reduced by stilbestrol approximately two-fifths of a grade in both the HE–HP and the LE–LP groups and approximately one-fourth of a grade in both the HE–LP and the LE–HP groups. Stilbestrol failed significantly to affect feed consumption.

Stilbestrol, Protein, and Energy. No interactions pertaining to estimated energy consumption, average daily gains or liveweight grade were detected between stilbestrol, protein, and energy. However, the increases in average daily gains due to stilbestrol were greatest in the HE–LP and LE–HP groups. These findings do not fully confirm the work of Preston and Burroughs (1958) who reported more stimulation from stilbestrol with HE–HP rations than with LE–LP rations. Preston and Burroughs (1958) further suggested interactions due to the combined influence of protein and energy on the effect of stilbestrol. No interactions between stilbestrol and energy on daily gains, liveweight grade and feed efficiency were demonstrated in the present trial. However, an interaction between stilbestrol and energy is apparent in salt consumption. Salt was the only part of the diet fed free-choice.

Summary

A 2^3 factorially arranged feeding trial was conducted with 16 groups of 12 fattening lambs each to evaluate the response of lambs fed different amounts of protein and energy with and without stilbestrol.

Interactions between digestible protein and ENE fed at 90 and 120% of recommended amounts were detected for liveweight gains, grades and feed efficiencies. The lambs fed the high energy rations apparently required more protein than those fed the low energy rations to maintain feed intake and growth rate.

Lambs receiving the high level of protein gained faster, graded higher and were more efficient than those fed the low level. Differences between energy levels were not observed. Actually differences existed between energy levels within each protein level but were in a different direction within each protein level and were detected as a protein by energy interaction.

Stilbestrol significantly increased average daily gains (approximately 0.05 lb. per day) and feed efficiency (5.42 vs. 4.49 therms ENE required per lb. gain) but decreased liveweight grade approximately one-third of a grade. No interactions were detected between stilbestrol, protein and energy in liveweight gains or grades.

Literature Cited

Andrews, F. N., W. M. Beeson and C. Harper. 1949. The effect of stilbestrol and testosterone on the growth and fattening of lambs. J. Animal Sci. 8:578.

Bosshardt, D. K., W. Paul, K. O'Doherty and R. H. Barnes. 1946. The influence of calorie intake on the growth utilization of dietary protein. J. Nutr. 32:641.

Davey, R. J. and G. H. Wellington. 1959. Studies on the use of hormones in lamb feeding. I. Production performance. J. Animal Sci. 18:64.

Donaldson, W. E., G. F. Combs, G. L. Romoser and W. C. Supplee. 1955. Body composition, energy intake, feed efficiency, growth rate, and feather condition of growing chickens as influenced by calorie-protein ratio of the ration. Poul. Sci. 34:1190.

Hartman, R. H., D. L. Staheli, R. G. Holleman and L. H. Horn. 1958. Effect of stilbestrol, pelleting and concentrate to roughage ratio on the performance and quality of fattening lambs. J. Animal Sci. 17:1173 (Abstract).

Hill, F. W., L. B. Carew, Jr. and Ruth Renner. 1956. Studies of the efficiency of energy utilization by the growing chick. Proc. Cornell Nutr. Conf. p. 31.

Jones, J. R., D. E. Hogue and G. L. Hunt. 1958. Effect of energy level on protein requirement of lambs fattened with and without stilbestrol. J. Animal Sci. 17:1171 (Abstract).

Lofgreen, G. P., J. K. Loosli and L. A. Maynard. 1951. The influence of energy intake on the nitrogen retention of growing calves. J. Dairy Sci. 34:911.

Meyer, J. H. 1958. Interactions of dietary fiber and protein on food intake and body composition of growing rats. Am. J. Physiol. 193:488.

Morrison, F. B. 1957. Feeds and Feeding (22nd ed.). The Morrison Publishing Co., Ithaca, New York.

Preston, R. L. and W. W. Burroughs. 1958. Stilbestrol responses in lambs fed rations differing in calorie to protein ratios. J. Animal Sci. 17:140.

Snedecor, G. W. 1956. Statistical Methods. Iowa State College Press, Ames. Iowa.

RATIOS OF DRIED SKIMMILK AND DRIED WHEY FOR PIG STARTER RATIONS[1]

D. M. DANIELSON,[2] E. R. PEO, JR. AND D. B. HUDMAN

Nebraska Agricultural Experiment Station,[3] Lincoln

LACTOSE and sucrose were reported by Hudman (1956) to be preferred carbohydrates for pig starter rations. Lactose gave the best growth response when fed with soybean oil meal; sucrose with milk protein. From the analysis listed by Morrison (1956), both dried skimmilk and dried whey must be considered as a source of lactose since, on an average, these products contain 51.1 and 70.1% lactose, respectively. In addition, both contain a high quality protein.

In 1953, Crane observed that pigs gained more rapidly on a ration containing 40% dried skimmilk than on one containing 35% dried skimmilk and 10% dried whey. Hanson *et al.* (1957) reported that dried skimmilk improved a 50% dried whey diet for young pigs. Meade *et al.* (1957) when studying dry formulas for baby pigs used rations containing 10% sugar with dried whey at levels from 5 to 30%. The addition of whey increased weights of the pigs from 3 to 11%.

It was the purpose of this experiment to determine the effect of various combinations of dried skimmilk and dried whey on gains and feed efficiency of baby pigs and to determine the effect of these combinations on the subsequent performance of the pigs.

Experimental Procedure

Sixty Landrace x Yorkshire crossbred pigs, weaned at an average age of 15.8 days and weight of 9.5 lb., were allotted at random within weight outcome groups, within litters, to three replications of six experimental treatments. One replication consisted of four pigs per pen and two replications consisted of three pigs per pen.

The pens of the experimental unit were concrete-floored and were equipped with automatic waterers and self-feeders. The pens were cleaned daily and wood shavings were used for bedding. The experimental unit was equipped with a thermostatically-controlled heating system. Unit temperature was decreased approximately 5° F. each of four weeks from an initial temperature of 85° F. Prior to being started on test, the pigs were fed a pre-starter ration (composition, table 1) for a three-day period to initiate

[1] Published with the approval of the Director as Paper No. 1028, Journal Series, Nebraska Agricultural Experiment Station.

[2] Present address: North Platte Experiment Station, North Platte, Nebraska.

[3] Department of Animal Husbandry. Acknowledgment is made to F. Krieger for his assistance in caring for the experimental animals and to Midwest Dried Milk Company, Dundee, Illinois for the dried whey used in this experiment.

consumption of dry feed by all pigs before allotment to the experiment.

All experimental rations, except the corn basal ration, were formulated to contain lactose in an amount equivalent to that found in the 40% dried whey ration. Feed-grade lactose, ground yellow corn and soybean oil meal were varied to equalize the lactose and protein levels between treatments. The six rations contained equal amounts of sucrose; their respective compositions are shown in table 2.

The pigs were fed these rations for a 28-day period. At the end of this initial 28-day test period, one pig was removed from each of the pens in

TABLE 1. COMPOSITION OF PRE-STARTER RATION [a]

Ingredient	Percent in ration
Carbohydrate mix [b]	41.25
50% solvent soybean oil meal	7.00
Dried skimmilk (low heat, spray dried)	40.00
Fish meal (herring)	5.00
Lard (stabilized)	2.50
Dried brewers yeast	1.00
Trace minerals [c]	0.15
Dicalcium phosphate	0.35
Ground limestone	0.25
Salt (iodized)	0.50
Vitamin-antibiotic premix [d]	2.00

[a] Calculated content of protein, 22.1%; calcium, 0.8%; phosphorus, 0.65%.
[b] Includes 40 parts sucrose, 30 parts dextrose and 30 parts corn (finely ground).
[c] Calcium Carbonate Company, std. swine mix.
[d] Contributed the following amounts of vitamin and antibiotics per lb. of complete ration: vit. A, 1410 I.U.; vit. D_3, 450 I.U.; riboflavin, 1.0 mg.; niacin, 1.75 mg.; calcium pantothenate, 3.0 mg.; choline chloride, 80 mg.; pyridoxine, 2.0 mg.; thiamine, 2.0 mg.; menadione, 1.0 mg.; vit. E, 1.0 mg.; vit. B_{12}, 20 mcg.; butylated hydroxy toluene, 57 mg.; oxytetracycline, 30 mg.; bacitracin, 10 mg.; penicillin, 10 mg.

the replication consisting of four pigs per pen in order to avoid a shortage of pen space in the next test period. It was decided before the experiment was started that the lightest pig would be removed since larger, heavier pigs are usually stronger competitors for feed, water, and pen space. For the next 28 days, the pigs remaining on test were all fed the same grower ration (composition, table 3) so that an observation could be made on the effect of previous treatment upon subsequent performance. Pig weights and feed data were collected at weekly intervals throughout the test period. The pen-of-pigs was used as the experimental unit and the data were analyzed by analysis of variance (Snedecor, 1956). The Q-test was used to evaluate differences between treatment means. All statements concerning statistical significance are at a probability level of 5% or less.

Results and Discussion

As shown in table 4, the greatest total gain (6.1 lb.) for the first 14-day period was made by the pigs fed the ration containing 30% dried skimmilk

TABLE 2. PERCENTAGE COMPOSITION OF STARTER RATIONS

Treatment no.[a]	1 (Pos. control basal)	2	3	4	5	6 (Neg. control basal)
Dried skimmilk (low heat, spray dried) (DSM)	40.00	30.00	20.00	10.00	.....	.....
Dried whey (roller dried) (DW)	.....	10.00	20.00	30.00	40.00	.....
Ground yellow corn	30.45	27.50	24.54	21.47	18.35	52.85
Lactose (feed grade)	7.15	5.37	3.58	1.79	.....	.....
Sucrose	10.00	10.00	10.00	10.00	10.00	10.00
50% solvent soybean oil meal	3.10	7.73	12.33	17.04	21.85	26.30
Fish meal (herring)	2.50	2.50	2.50	2.50	2.50	2.50
Lard (stabilized)	2.50	2.50	2.50	2.50	2.50	2.50
Dried brewers yeast	1.00	1.00	1.00	1.00	1.00	1.00
Trace minerals[b]	0.15	0.15	0.15	0.15	0.15	0.15
Dicalcium phosphate	0.20	0.30	0.35	0.50	0.55	1.35
Ground limestone	0.45	0.45	0.55	0.55	0.60	0.85
Salt (iodized)	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin-antibiotic premix[c]	2.00	2.00	2.00	2.00	2.00	2.00

[a] For all rations, calculated content of protein, 20%; calcium, 0.80%; phosphorus, 0.60%.
[b] Calcium Carbonate Company, std. swine mix.
[c] Contributed the following amouts of vitamins and antibiotics per pound of complete rations: vit. A, 1695 I.U.; vit. D_2, 400 I.U.; riboflavin, 1.0 mg.; niacin, 7.0 mg.; choline chloride, 86 mg.; thiamine, 1.0 mg.; menadione, 1.0 mg.; vit. E, 5.0 mg.; vit. B_{12}, 20 mcg.; butylated hydroxy toluene, 57 mg.; oxytetracycline, 25 mg.

(DSM) and 10% dried whey (DW). Gains decreased when the level of dried whey was increased above 10% in the ration. Regression analysis of the effect of DW levels on gain revealed that the linear component was significant. There was no significant difference in gain between the 30–10 (DSM–DW) treatment and the 40% DSM basal diet. The least gain (2.8 lb.) was made by the pigs fed the corn basal ration.

TABLE 3. COMPOSITION OF GROWER RATION[a]

Ingredient	Percent in ration
Dried whey (roller-dried)	5.00
Ground yellow corn	71.80
Fish meal (herring)	2.50
50% meat and bone meal	2.50
50% solvent soybean oil meal	14.25
Lard (stabilized)	1.50
Ground limestone	0.65
Dicalcium phosphate	0.20
Salt (iodized)	0.50
Trace minerals[b]	0.10
Vitamin-antibiotic premix[c]	1.00

[a] Calculated content of protein, 16.1%; calcium, 0.70%; phosphorus, 0.50%.
[b] Calcium Carbonate Company, std. swine mix.
[c] Contributed the following amounts of vitamins and antibiotics per pound of complete ration: vit. A, 1700 I.U.; vit. D_2, 180 I.U.; riboflavin, 2.3 mg.; niacin, 13.7 mg.; calcium pantothenate, 11.3 mg.; choline chloride, 113.5 mg.; vit. B_{12}, 10 mcg.; oxytetracycline, 20 mg.

TABLE 4. EFFECT OF DRIED WHEY LEVELS ON PIG GAINS AND FEED EFFICIENCY

Treatment and ration designation	1 40% DSM basal	2 30% DSM 10% DW	3 20% DSM 20% DW	4 10% DSM 30% DW	5 40% DW	6 Corn basal	Q $s\bar{x}$ [a] treatments 1 through 6
Pigs per treatment, no.[b]	10	10	10	10	10	10	...
Av. initial wt., lb.	9.4	9.5	9.4	9.4	9.5	9.5	...
Av. gain (first 14 days), lb.[c, d]	5.2	6.1	4.8	4.1	3.6	2.8	3.2
Av. feed per lb. gain (first 14 days), lb.[d, e]	2.05	2.00	2.23	2.85	3.22	4.19	2.21
Av. gain (28 days), lb.	16.3	17.7	16.0	17.0	14.1	10.8	9.9
Av. feed per lb. gain (28 days), lb.[d, e]	1.70	1.94	1.88	2.01	2.29	2.51	0.46
			Subsequent performance[f] (28 days)				
Av. total gain, lb.	33.2	33.6	36.0	38.4	34.1	33.4	14.4
Av. feed per lb. gain, lb.	2.17	2.10	2.11	2.16	2.15	2.21	0.38

[a] Difference required between the six treatment means for significance at P=0.05 or less.
[b] Four pigs per pen replicate 1; 3 pigs per pen replicates 2 and 3.
[c] Linear regression of dried whey levels on first 14-day gain significant at P=0.05 or less.
[d] Error mean squares, treatments 1–5. Gain=1.5373, 14.9952; Feed=0.3280, 0.0252, for 14 and 28 days, respectively.
[e] Linear regression of dried whey levels on feed required per pound of gain significant at P=0.05 or less.
[f] Average of 9 pigs per treatment.

During the first 14-day period, the pigs fed the 30–10 (DSM–DW) ration treatment required only 2 lb. of feed per pound of gain which was less than that required by the pigs fed the other ration treatments. The amount of feed required per pound of gain increased as the level of DW was increased above 10%. This linear effect of DW levels on feed required per pound of gain was significant. The pigs fed the 40% DW and the corn basal rations required 3.22 and 4.19 lb. of feed per pound of gain, respectively. This was considerably greater than that required by the pigs fed the other ration treatments although the differences were not significant.

For the 28-day test period, the pigs fed the 30–10 (DSM–DW) treatment gained 1.4 lb. more than those fed the 40% DSM diet. This differs from the study by Crane (1953) who observed that pigs fed a ration containing 40% DSM made more rapid and efficient gains than those fed a basal ration containing 35% DSM and 10% DW. In the present study, gains were reduced with the 40% DW diet. The difference between the gain of the pigs fed the 40% DW diet and those fed the 30–10 (DSM–DW) ration (3.6 lb.) was significant. Again, the least gain was made by the pigs fed the corn basal ration.

Except for the 20–20 (DSM–DW) treatment, the amount of feed required per pound of gain increased as the level of DW was increased in the ration. Even though the 20–20 (DSM–DW) treatment deviated, regression analysis showed that the linear effect of DW levels on feed required per pound of gain was significant. The pigs fed the corn basal ration required 2.51 lb. of feed per pound of gain which was the most feed required per pound of gain for any of the ration treatments.

As previously mentioned, at the end of the initial 28-day test period, all pigs were fed the same 16% protein grower ration for an additional 28 days in order to study the effect of previous treatment upon subsequent performance of the pigs. From the data shown in table 4, pigs which were fed rations containing dried whey during the initial 28-day period made greater gains during the subsequent period than those which had been fed the ration containing 40% DSM. The greatest total gain was made by the pigs which had been fed the 10–30 (DSM–DW) ration treatment during the initial 28-day period. Pigs fed the corn basal diet made the least gain during the initial period but made gains comparable to the other pigs during the subsequent period. However, these pigs did not weigh as much at the end of the 56-day test period as the pigs fed the other rations. There was no significant difference in the amount of feed required per pound of gain by the pigs fed the various rations. The pigs fed the corn basal ration required the most feed per pound of gain throughout the experiment.

Discussion. Lactose, a major carbohydrate source furnished by treatments 1 through 5, was probably a more acceptable digestible substrate for the enzymes elaborated by the baby pig than was that furnished by the corn (negative control) diet. This is suggested by the work of Bailey *et al.* (1956) who observed, when measuring the activity of intestinal lactase,

sucrase and maltase of suckling pigs, that lactase had the highest activity from birth to weaning. It would appear then that lactose contributed to the improvement in gains and feed efficiency shown by the pigs fed diets containing milk products as compared to those fed the corn basal diet.

However, not all of the improvement can be attributed to lactose. Protein source also appears to be involved. This is apparent from the reduction in gains and feed efficiency observed when dried whey levels were increased above 10%. Since all rations (except the corn basal) were formulated with equivalent amounts of lactose, gains and feed efficiencies should have been the same on treatments 1 through 5 if lactose were the only factor involved. It is obvious from the data that this was not the result. When whey was used to replace dried skimmilk in the rations, soybean oil meal was used to maintain a constant protein level. Thus, as the whey level was increased in the ration, total ration protein from soybean oil meal increased. According to the work of Lewis *et al.* (1955), baby pigs can not fully utilize soybean oil meal. Thus, the reduction in gains and feed efficiency observed when dried whey levels were increased above 10% may have been caused by the decrease in total protein coming from milk sources.

Other factors such as minerals (other than calcium and phosphorus) should not be ignored. However, at no time during this study was there any evidence of a whey-induced diarrhea. This is in agreement with a study conducted by Becker *et al.* (1957) who found no evidence of a whey-induced diarrhea when dried whey was substituted for dextrose at levels of 30 and 60%.

The dried skimmilk and dried whey used in this experiment were of excellent quality. Considering the wide variation in samples of these two products, it is possible that other sources might produce different results.

Summary

Sixty Landrace x Yorkshire crossbred pigs were used to evaluate ratios of dried skimmilk and dried whey for pig starter rations. In addition, the effect of starter treatment upon the subsequent performance of the pigs was studied. The greatest gain and feed efficiency was made by the pigs fed a ration containing 30% dried skimmilk and 10% dried whey during the starter period. Gains and feed efficiency decreased when the dried whey level was increased above 10%.

Pigs fed starter rations containing dried whey made greater gains during the subsequent period than those fed a 40% dried skimmilk starter ration. There was no significant difference in the amount of feed required per pound of gain by the pigs during the subsequent feeding period.

Literature Cited

Bailey, C. B., W. D. Kitts and A. J. Wood. 1956. The development of the digestive enzyme system of the pig during its pre-weaning phase of growth. B. Intestinal lactase, sucrase and maltase. Can. J. Agr. Sci. 36:51.

Becker, D. E., S. W. Terrill, A. H. Jensen and L. J. Hanson. 1957. High levels of dried whey in the diet of swine. J. Animal Sci. 16:404.

Crane, F. M. 1953. A study of diets (dry) designed for weaning the baby pig at an early age (10 lbs. or less). J. Animal Sci. 12:912. (Abstract).

Hanson, L. J., D. E. Becker, A. H. Jensen and S. W. Terrill. 1957. Factors affecting the nutritive value of dried whey and its utilization in swine diets. J. Animal Sci. 16:1039. (Abstract).

Hudman, D. B. 1956. Evaluation of carbohydrates for baby pigs. Ph.D. Thesis, Iowa State College Library, Ames, Iowa.

Lewis, C. J., D. V. Catron, C. H. Liu, V. C. Speer and G. C. Ashton. 1955. Enzyme supplementation of baby pig diets. J. Agr. Food Chem. 3:1047.

Meade, R. J., L. E. Hanson, R. M. Prouty and W. S. Teter. 1957. Dry formulas for pigs weaned at 2 and 3 weeks of age. Minn. Agr. Exp. Stat. Mimeo. H–144.

Morrison, F. B. 1956. Feeds and Feeding. (22nd ed.). The Morrison Pub. Co., Ithaca, New York.

Snedecor, G. W. 1956. Statistical Methods (5th ed.). Iowa State College Press, Ames, Iowa.

INFLUENCE OF YEAR AND SEASON OF BIRTH, SEX, SIRE, AND AGE OF DAM ON WEIGHTS OF BEEF CALVES AT 60, 120, 180 AND 240 DAYS OF AGE [1, 2]

C. J. BROWN

Arkansas Agricultural Experiment Station, Fayetteville

THE proper evaluation of identifiable sources of variation in calf weights aids in more accurate appraisal of genetic differences in mothering ability among beef cows. Correction factors have been presented in several studies for the effects of sex, year of birth, season of birth, sire and age of dam at weaning. The age at which calves were weaned varied considerably. In only a few cases were factors influencing calf weights prior to weaning evaluated. In the present study estimates of the magnitude and relative importance of the effects of sex, year and season of birth, sire and age of dam, on calf weights in three herds of cattle were made at four ages during the pre-weaning growth period.

Material and Methods

The data used in this study were the weights of beef calves raised on Arkansas Agricultural Experiment Station farms. These calves were from three herds, designated as Herd H, A_1 and A_2. Herds H and A_1 were purebred Hereford and Aberdeen Angus herds respectively which were maintained as separate units under similar conditions at the Main Station near Fayetteville. Cows in herds H and A_1 foraged over 10 to 15 acres of permanent pasture of brush, low quality native grasses of the Ozark region, common Bermuda grass and lespedeza. The pasture terrain was rocky and steep. Grass hay and a protein supplement, equivalent to about 2 lb. of cottonseed cake, were fed for approximately 150 days each year depending on the length and severity of the winter season. The purebred Aberdeen Angus herd designated as A_2 was maintained under an intensive system of management at the Livestock and Forestry Branch Experiment Station near Batesville. In this herd cows foraged over 2 to 3 acres of highly fertilized permanent pasture of grass-legume mixtures. During mid-summer, temporary supplemental pastures of sudan and lespedeza were frequently used. Small grain pastures were abundant during the fall and were sufficient in most years so that only small amounts of silage, hay and protein supplement were necessary during mid-winter to maintain a high level of nutrition. Calves in Herd A_2 were creep fed during winter months. Calves in Herds H and A_1 received no creep feed.

[1] Published with the approval of the Arkansas Agricultural Experiment Station.
[2] A publication of the Southern Regional Beef Cattle Breeding Project, S–10.

Calves were weighed monthly and weaned on the weigh day of their seventh month. Calves in Herd A_2 were born during all months of the year although fewer were born during summer. In herds H and A_1 calves were born during 60-day calving periods in either the fall or the spring. The weight of each calf was determined at 60, 120, 180 and 240 days of age by interpolation, using the weights and average daily gain during the approximately 30-day interval which bracketed the age to which it was desired to standardize.

Each calf was classified according to year and season of birth, sire, sex and age of dam. Least squares analyses were used to estimate parameters in each herd at 60, 120, 180 and 240 days of age according to the model, $Y_{ijklmn}=u+A_i+B_j+S_k+F_l+D_m+e_{ijklmn}$, where in the respective herds:

	H	A_1	A_2
Year	i=1,...7	i=1.....9	i=1.....9
Season	j=1, 2	j=1, 2	j=1.....4
Sire	k=1,...10	k=1,....11	k=1,....9
Sex	l=1, 2	l=1, 2	l=1, 2
Dam	m=1,.... 8	m=1,.....8	m=1.....8

In the model, Y_{ijklmn} is the weight of a calf at a particular age, u is an effect common to all calves, A_i is an effect due to year of birth, B_j is an effect due to season of birth, S_k is an effect due to sire of calf, F_l is an effect due to sex of calf, D_m is an effect due to age of dam, and e_{ijklmn} is an effect peculiar to the individual calf. It was assumed that there were no interactions between effects and that the e_{ijklmn}'s were normally distributed, had an expectation of zero, the same variance and were uncorrelated. The hypothesis that each of the effects listed in the model was zero was tested by analysis of variance computed at each age, in each herd. The sum of squares associated with an effect was determined as the difference in the reduction in the sum of squares due to fitting constants for the above model as compared to the sum of squares due to fitting constants in a similar model differing only in that the effect being tested was omitted. Using appropriate degrees of freedom and sums of squares, the mean squares were computed. Components of variance were derived by equating mean squares to expected mean squares. The procedures followed in these analyses are described by Anderson and Bancroft (1952).

Results and Discussion

In separate analyses for each herd at each age, a set of normal equations were solved for the parameters, estimates of which are shown in table 1. The values shown in table 1 are least squares estimates of the deviation in weight from a heifer calf born in the spring of 1958 from a fifth lactation dam and from the sire within each herd which had progeny in the most years. Since the same sires were not used in the different herds, the sire

TABLE 1. LEAST SQUARE ESTIMATES OF THE INFLUENCE OF YEAR, SEASON, SIRE, SEX, AND AGE OF DAM ON WEIGHT OF BEEF CALVES

Items	Herd H, age of calf (days)								Herd A_1, age of calf (days)								Herd A_2, age of calf (days)							
	60		120		180		240		60		120		180		240		60		120		180		240	
Mean	165	7[a]	295	15	373	21	405	28	157	6	252	9	366	13	427	16	179	8	245	12	353	17	394	20
Year:																								
1950	...		...		...		...		19	12	25	19	35	27	74	33	7	15	67	21	46	30	103	36
1951	...		...		...		...		3	7	17	12	0	17	15	22	—3	15	42	21	23	30	79	36
1952	—5	8	—38	17	—2	24	30	31	—4	7	19	11	17	15	36	19	0	13	48	18	32	26	86	32
1953	4	8	—30	16	—2	23	43	30	0	7	4	11	—8	15	6	20	0	12	47	17	45	24	79	30
1954	0	8	—19	16	33	24	48	31	3	6	17	10	12	15	—2	18	4	10	27	14	15	20	31	24
1955	0	8	—29	15	—31	22	—15	29	—1	6	11	9	—17	13	—34	17	—1	8	39	12	27	17	50	20
1956	—3	5	—34	12	—30	17	—37	22	13	5	12	9	—6	13	—20	16	0	9	26	13	36	19	70	24
1957	2	5	—22	11	0	16	8	21	6	6	8	10	—19	14	—34	18	0	7	20	11	9	16	28	19
1958	0		0		0		0		0		0		0		0		0		0		0		0	
Season:																								
Fall[b]	—11	3	—39	5	—66	8	—36	10	—12	3	—42	5	—64	7	—39	9	—1	4	—12	5	—5	8	19	9
Winter	...		...		...		...		...		...		...		...		7	4	28	6	4	8	21	9
Spring	0		0		0		0		0		0		0		0		0		0		0		0	
Summer	...		...		...		...		...		...		...		...		—3	6	—12	8	—2	11	21	13
Sires[c]	—3	5	—10	8	—18	12	—26	17	—11	6	—21	9	—31	13	—38	16	—8	11	—32	15	—22	23	—43	27
	15	6	16	10	17	14	21	18	0	5	—10	8	—30	12	—54	15	—2	9	—11	12	—13	18	—20	21
	—21	7	—30	11	—43	15	—39	21	0	7	0	10	—3	15	8	17	—7	8	—19	10	—23	15	—22	19
	—4	10	2	16	0	23	11	29	0	6	—6	8	—14	12	—18	16	0		0		0		0	
	0		0		0		0		—9	6	—3	9	—3	13	23	29	—29	11	8	16	—4	23	10	31
	—18	6	—25	9	—41	13	—36	17	—21	7	—32	12	—47	16	—39	23	1	8	—5	11	—12	17	—58	22
	—25	6	—42	10	—65	15	—70	18	—17	6	—27	9	—26	13	—24	17	—26	7	—11	11	—15	15	—7	19
	—8	10	—4	16	14	25	47	37	—6	6	—6	8	0	12	—2	15	—10	10	4	13	5	19	—1	24
	—2	6	—16	10	—15	15	—14	20	0		0		0		0		5	11	20	16	30	24	25	30
	—13	13	—40	22	—43	32	—52	41	—1	13	13	19	8	28	—9	36	...		...		...		...	
	...		...		...		...		15	7	...		...		...		...		...		...		...	
Sex of calf:																								
Male	11	3	17	4	30	6	57	8	8	2	12	4	18	5	33	7	9	3	16	4	19	5	22	7
Female	0		0		0		0		0		0		0		0		0		0		0		0	
Lactation:																								
1st	—28	5	—37	8	—36	12	—30	16	—17	5	—17	7	—14	10	—11	13	—40	5	—52	7	—64	10	—74	12
2nd	—11	5	—13	8	—17	12	—35	16	—6	5	—5	7	—2	10	2	13	—26	5	—29	7	—36	10	—48	12
3rd	—3	5	0	9	—6	12	—14	16	4	5	3	8	9	11	10	14	—21	5	—21	7	—17	11	—18	13
4th	2	5	3	9	8	12	13	17	0	5	3	8	6	12	6	15	—22	6	—22	8	—22	11	—32	14
5th	0		0		0		0		0		0		0		0		0		0		0		0	
6th	1	6	3	10	6	15	26	20	0	6	6	10	10	14	34	18	—10	6	5	9	9	12	—11	15
7th	—14	7	—27	11	—28	15	—29	21	7	8	21	12	33	16	33	20	—9	7	3	10	0	15	6	19
8th	—5	6	—2	10	17	15	18	19	—3	7	0	11	9	15	29	20	—18	7	—11	10	—18	14	—20	17
No. calves	287		267		260		253		334		314		309		277		272		272		252		209	

[a] Values in second columns are standard errors ±.
[b] Season designation indicates date of birth: Fall, Sept.–Nov.; Winter, Dec.–Feb.; Spring, Mar.–May; Summer, June–Aug.
[c] Sires in each herd were used only in that herd.

[c] Calves in each herd were classified as follows: Season of Birth: Fall, Sept.–Nov.; Winter, Dec.–Feb.; Spring, Mar.–May; Summer, June–Aug.
[d] Sires in each herd were used only in that herd.

TABLE 2. PERCENTAGE OF VARIANCE ASSOCIATED WITH YEAR, SEASON, SIRE, SEX AND AGE OF DAM IN THE ANALYSIS OF WEIGHTS OF CALVES AT 60, 120, 180, AND 240 DAYS OF AGE

Age of calf	60 days[a]			120 days			180 days			240 days		
Herd	H	A_1	A_2	H	A_1	A_2	H	A_1	A_2	H	A_1	A_2
Years	[b]	2.1*	[b]	1.8*	[b]	4.1**	7.0**	2.0*	2.1	8.0**	6.4**	6.0**
Seasons	5.5**	7.3**	0.0	20.5**	28.4**	15.4**	25.2**	31.9**	[b]	4.9**	9.3**	1.6**
Sires	10.5**	5.5**	4.4**	7.8**	3.2**	1.0	7.0**	2.8**	[b]	5.1**	3.4*	1.7
Sex	7.7**	4.3**	7.0**	6.1**	4.4**	7.2**	8.0**	4.5**	6.5**	21.7**	11.9**	5.5**
Age of dam	14.3**	8.0**	20.2**	9.5**	3.4**	20.0**	4.5**	1.8*	22.5**	4.8**	1.6	20.9**
Remainder	62.1	72.7	68.1	54.2	60.8	52.3	48.4	56.9	68.9	55.6	67.3	64.3

[a] A_1=Purebred Aberdeen-Angus maintained at Main Experiment Station, Fayetteville. A_2=Purebred Aberdeen-Angus maintained at Livestock and Forestry Branch Station, Batesville. H=Purebred Hereford maintained at Main Experiment Station, Fayetteville.
* Component calculated from a significant mean square, $P<.05$.
** Component calculated from a highly significant mean square, $P<.01$.
[b] Indicates that the variance component for the effect in that herd was negative and assumed to be zero.

in each herd that was used in the most years was chosen as the reference sire. These estimates would serve as correction factors if signs were reversed. Significance of differences and the percentage of variance associated with each of the effects studied are presented in table 2.

During the seven years in which all three herds were observed, weights at 240 days differed by 85, 70 and 86 lb. in herds H, A_1 and A_2, respectively. These differences are of similar magnitude to those noted at weaning by Burgess *et al.* (1954), Rollins and Guilbert (1954) and by other workers who have studied yearly weight variation in this way. Year effects among younger calves were smaller and in several cases non-significant. None of the negative components of variance was based on significant mean squares. At 240 days, differences among years accounted for 6 to 8% of the total variance. In herds A_1 and A_2 there was a distinct decline in constants associated with years. It may be that this decline was the result of a bias associated with culling cows which differed from the herd average in production rather than to any general deterioration of environment during the years studied. Henderson (1949) pointed out that bias may arise in this manner. More recently Henderson *et al.* (1959) elaborated on the origin of this bias and discussed methods for estimating environmental trends.

Fall calves were lighter than spring calves in all comparisons in table 1 except at 240 days in Herd A_2. This would reflect the lower nutritional level during winter months. That this seasonal difference was less noticeable in herd A_2 appears to indicate the influence of supplemental pastures and creep feed on growth and suggests the extent to which these practices might be used to standardize preweaning environment. Marlowe and Gaines (1958) in their study of data from the Virginia performance testing program noted that creep feeding decreased the influence of season of birth on growth. There was a consistent increase in the difference between weights of fall and spring calves up to the age of 180 days in herds H and A_1. This difference in both herds was less at 240 days of age. The decline in influence of season at 240 days of age may indicate the extent to which calves were grazing toward the end of the suckling period. Creep feeding was not practiced in these two herds and abundant young succulent tender grass became available in mid April just after the 180-day weights of fall-born calves. It has been suggested by Gifford (1953) and Drewry (1959) that calves are able to utilize grass toward the end of the preweaning growth period to compensate for low milk production of dams. Seasonal differences were significant in all cases except at 60 and 180 days in herd A_2. The percentage of variance associated with season was quite variable but consistent with differences in herd management and age of calf. The fact that in several cases more than twenty percent of the total variance was associated with season while in other cases this variance was less than ten percent of the total variance, indicates the need for consideration of age of calf and system of management in the correction of calf weights for the effect of season of birth.

In herd H, A_1, and A_2 the differences between the average adjusted weights of calves from the best and poorest sires used were 117, 77, and 83 lb., respectively, at 240 days. These differences, similar in magnitude to those recorded by other workers, appear large enough to justify correcting the record of a cow for the sire to which she was mated. Sire differences were significant at all four ages in herd H, and A_1 but were significant in herd A_2 only at 60 days of age. Differences in sire effects observed among herds may have been due to location, differences in management or to the fact that the sires for each herd were unique for that herd. Less than 11% of the total variance was associated with sire effects.

Differences between male and female calves were similar to those recorded by other workers in that males were heavier than females. The weight difference in pounds between male and female calves at weaning has been reported as 22 by Knapp *et al.* (1942); 23 by Koch (1951); 32 by Koger and Knox (1945); 28 by Woolfolk and Knapp (1949); 3 and 14 by Gregory *et al.* (1950); 26 by Koch and Clark (1955) and 38 by McCormick *et al.* (1956). Male calves were not classified as to steers or bulls since castration effects and selection practiced in deciding which calves were to remain bulls could not be separated. In all three herds it was the practice to leave all calves intact until the weight during the fourth month was taken, after which a small percentage of the calves was castrated. These were, in general, calves that were ineligible for registry in their respective breed associations. The percentage of males castrated in the three herds was approximately equal although slightly higher in herd A_2 during the early years of the study. By 240 days of age the sex difference in the three herds was 57, 33 and 22 lb. for H, A_1 and A_2, respectively. In herd A_2 the increase in size of the sex difference appears linear when plotted against age whereas in herds H and A_1 this relationship appears curvilinear. These observations would support the suggestion by Koch *et al.* (1959) that the shape of the growth curve in addition to the general magnitude of the gains may affect the observed difference between the sexes. In practice this would mean that sex correction factors developed in environments other than those for which they were to be used would in general be less accurate.

There was an increase in the weight of calves associated with an increase in age of dam during the early years of production and a subsequent decline in calf weight after the years of peak production. This was evident at all four ages at which calf weights were studied and indicates in general the same age of dam effects that have been reported by Knapp *et al.* (1942), Burgess *et al.* (1954), Rollins and co-workers (1954, 1956) and Koch and Clark (1955). In herds H and A_1 there was only a slight decline in production of the older dams, similar to that noted by Brown (1958) in data accumulated in earlier years from these same herds. The time required to reach mature production appeared distinctly different in these three herds. In herds H and A_1 it appeared that mature production was reached by the

third or fourth lactation whereas in herd A_2 mature production did not appear to be reached until at least the fifth or sixth lactation. Although the age at which cows first calved might influence the age at which mature production was reached, this would not appear to be a factor since the average age in months of first calving was 33, 33, and 32, in herds H, A_1 and A_2, respectively. The estimates of differences between age of dam groups would be biased upward from the true age effect as described by Koch and Clark (1955) and Lush and Shrode (1950) since comparisons would be of all records made by cows at each age. This bias is small and should be similar in these three herds because during the period studied, cow herds were being increased in size. Because of the effort to increase herd size only a few heifers were not returned to the herd. Cows were removed from the herds only for reasons which might be considered normal losses. Differences in location, management and nutritional level at which the herds were maintained may have influenced development of milk production and mothering ability. Bonsma (1943) pointed out differences in the trend of increase and decrease of milk yield with increase in age observed between Friesland cows in different countries of the world and in different areas of South Africa. He noted that under conditions where young cattle differed only slightly from mature production there was less decline at advanced ages. Greater milk production from dairy heifers developed under a limited feeding regime has been reported by Swanson (1957) Dalton *et al.* (1959) and Reid and co-workers (1957, 1957). In table 2 the age of dam effects were significant in all herds and at all ages except in Herd A_1 at 240 days of age. The percentage of variance associated with age of dam indicates that the relative importance of this effect as a source of variation was much less in herds H and A_1 than A_2. In these two herds there was a slight decline in the importance of age of dam as a source of variation from 60 to 240 days. In herd A_2, however, the percentage of variance associated with age of dam did not decline as the calf grew older and accounted for more than 20% of the variance at all four ages studied. These data would indicate need for the development of age of dam correction factors under environmental conditions similar to those where they are to be applied.

From 48 to 72% of the total variance was not accounted for by the model. This is indicated in table 2 by the remainder which corresponds to the $1-R^2$ in multiple regression. This term would include the variance due to differences among dams as well as that from other unmeasured and unknown sources.

Summary

Least squares estimates of the effects of year and season of birth, sex, sire, and age of dam on the weight of beef calves at 60, 120, 180 and 240 days of age were computed. Weight records of 893 calves were analyzed and studied separately for three herds. The size and statistical significance

of differences and the percentage of variance associated with the five factors studied appear large enough to justify correction of weight records at these ages in the evaluation of breeding animals. These data indicate the need for consideration of age of calf and system of management in the standardization of calf weight records for sex, season of birth, and age of dam. The development of correction factors for use under systems of management and environmental conditions similar to those under which they are to be applied is indicated.

Literature Cited

Anderson, R. L. and T. A. Bancroft. 1952. Statistical Theory in Research. McGraw-Hill Book Co., Inc., New York.

Brown, C. J. 1958. Heritability of weight and body dimensions of beef calves at weaning. Ark. Agr. Exp. Stat. Bul. 597.

Bonsma, F. N. 1943. The influence of environmental factors on the age-correction factors for milk yield of Friesland cows in South Africa. Union of South Africa, Dept. of Agr. & For., Agr. Res. Inst. Ser. No. 2, Bul. 242.

Burgess, J. B., Nellie L. Landblom and H. H. Stonaker. 1954. Weaning weights of Hereford calves as affected by inbreeding, sex and age. J. Animal Sci. 13:843.

Dalton, H. L., W. J. Miller and J. D. Donker. 1959. Effect of different levels of TDN intake on body weight and milk production. J. Dairy Sci. 42:934.

Drewry, K. J., C. J. Brown and R. S. Honea. 1959. Relationships among factors associated with mothering ability in beef cattle. J. Animal Sci. 18:938.

Gifford, Warren. 1953. Record of performance tests for beef cattle in breeding herds. Ark. Agr. Exp. Stat. Bul. 531.

Gregory, Keith E., Cecil T. Blunn and Marvel L. Baker. 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. J. Animal Sci. 9:338.

Henderson, C. R. 1949. Estimation of changes in herd environment. J. Dairy Sci. 32:706.

Henderson, C. R., Oscar Kempthorne, S. R. Searle and C. M. von Krosigk. 1959. The estimation of environmental and genetic trends from records subject to culling. Biometrics 15:192.

Koch, Robert M. 1951. Size of calves at weaning as a permanent characteristic of range Hereford cows. J. Animal Sci. 10:768.

Koch, Robert M., K. E. Gregory, J. E. Ingalls and R. L. Arthand. 1959. Evaluating the influence of sex on birth weight and pre-weaning gain in beef cattle. J. Animal Sci. 18:738.

Koch, Robert M. and R. T. Clark. 1955. Influence of sex, season of birth and age of dam on economic traits in range beef cattle. J. Animal Sci. 14:386.

Koger, Marvin and J. H. Knox. 1945. The effect of sex on weaning weight of range calves. J. Animal Sci. 4:15.

Knapp, Bradford, Jr., A. L. Baker, J. R. Quesenberry and R. T. Clark. 1942. Growth and production factors in range cattle. Mont. Agr. Exp. Stat. Bul. 400.

Lush, J. L. and Robert R. Shrode. 1950. Changes in milk production with age and milking frequency. J. Dairy Sci. 33:338.

Marlowe, Thomas J. and James E. Gaines. 1958. The influence of age, sex, season of birth of calf, and age of dam on preweaning growth rate and type score of beef calves. J. Animal Sci. 17:706.

McCormick, W. C., B. L. Southwell and E. J. Warwick. 1956. Factors affecting performance in herds of purebred and grade polled Hereford cattle. Ga. Agr. Exp. Stat. Tech. Bul. N.S. 5.

Reid, J. T., J. K. Loosli, K. L. Turk, S. A. Asdell and S. E. Smith. 1957. Progress report on a study of the effect of plane of early nutrition upon reproductive and productive performance of Holstein cattle. J. Dairy Sci. 40:610.

Reid, J. T., J. K. Loosli, K. L. Turk, G. W. Trimberger, S. A. Asdell and S. E. Smith. 1957. Effect of nutrition during early life upon the performance of dairy cows. Proceedings 1957 Cornell Nutrition Conference pp. 65–71.

Rollins, W. C. and H. R. Guilbert. 1954. Factors affecting the growth of beef calves during the suckling period. J. Animal Sci. 13:517.

Rollins, W. C. and K. A. Wagnon. 1956. A genetic analysis of weaning weights in a range beef herd operated under optimum and sub-optimum nutritional regimes. J. Animal Sci. 15:125.

Swanson, E. W. 1957. The effect of fattening dairy heifers upon their growth and lactation. J. Dairy Sci. 40:611.

Woolfolk, E. J. and Bradford Knapp, Jr. 1949. Weight and gain of range calves as affected by rate of stocking. Mont. Agr. Exp. Stat. Bul. 463.

INFLUENCE OF MINERAL SUPPLEMENTS ON THE GROWTH OF CALVES, DIGESTIBILITY OF THE RATIONS AND INTRA-RUMINAL ENVIRONMENT [1]

J. W. G. NICHOLSON,[2] J. K. LOOSLI AND R. G. WARNER

Cornell University, Ithaca, N. Y.

SEVERAL reports have shown that the addition of alfalfa hay or alfalfa ash to a ration containing starch and a low-ash roughage such as corn cobs or cottonseed hulls results in an improvement in digestibility of the ration (Burroughs *et al.*, 1950; Chappel *et al.*, 1955; Swift *et al.*, 1951; Tillman *et al.*, 1954b). How this response is elicited has not been satisfactorily explained although many suggestions have been proposed. It is possible that a change in the intra-rumen environment may be involved such as an alteration of pH, osmotic pressure, or the relative or absolute amounts of water, ash, volatile fatty acids and dry matter. Many of these factors have been studied singly or in pairs but no test seems to have been conducted in which they have been studied together.

This paper is concerned with the influence of mineral supplementation of a low-ash ration on intra-ruminal environment and the performance of the animal as exhibited by digestibility of the ration, feed consumption and growth. Relationships among the various factors observed have also been studied.

Experimental Procedure

Experiment I. Two-month-old calves (five heifers and three bulls per treatment) were used in a growth study which was conducted over an 8-week period. The calves were kept in individual box stalls. Feed and water were available *ad lib*. The composition of the rations used is given in table 1. Rations 2 and 3 consisted of the basal ration plus mineral supplement. This resulted in proportionate changes in the other ingredients. The alfalfa hay supplement in ration 4 replaced part of the corn cobs and soybean oil meal so that this ration had approximately the same crude protein and crude fiber content as the other rations. The basal ration (1) contained 14.7% protein, 21.7% crude fiber, 3.2% ash, 0.4% calcium and 0.4% phosphorus. The alfalfa hay was excellent quality, second cutting and contained 18.2% protein, 24.8% crude fiber, 7.2% ash, 1.5% calcium and 0.2% phopshorus. Rations 2 and 3 were similar to the basal ration in proximate composition but the calcium and phosphorus contents were, respectively, 0.9% and 0.5% for ration 2 (alfalfa ash supplement) and 0.5% and 0.4% for ration 3 (special minerals supplement). All rations

[1] Supported in part by a grant to Cornell University from the Herman Frasch Foundation.
[2] Present address: Experimental Farm, Nappan, N. S., Canada.

TABLE 1. PERCENTAGE COMPOSITION OF THE RATIONS

Supplement and ration	None 1	Alfalfa ash 2	Special mineral 3	Alfalfa hay 4
	Experiment I			
Corn cobs, ground	49.8	47.6	48.3	19.8
Corn starch	31.1	29.8	30.2	31.1
Soybean oil meal	14.9	14.3	14.5	5.0
Urea	1.99	1.90	1.93	1.99
Minerals[a]	2.12	2.02	2.05	2.11
Alfalfa hay	....	....	....	40.0
Alfalfa ash	....	4.40	....	....
Special minerals[b]	....	....	3.02	....

Supplement and ration	None 5	Low level alfalfa ash 6	High level alfalfa ash 7	Timothy hay 8
	Experiment II			
Corn cobs, ground	43.8	42.7	41.7	....
Corn starch	26.3	25.6	25.0	....
Soybean oil meal	8.8	8.5	8.3	16.4
Urea	1.93	1.88	1.83	....
Minerals[a]	1.58	1.54	1.50	1.48
Timothy hay	17.5	17.1	16.7	82.1
Alfalfa ash	....	2.56	5.00	....

[a] The mineral mixture in grams for Experiment I was: dicalcium phosphate, 90,800; iodized salt, 31,780; $FeSO_4 \cdot 7H_2O$, 590; $CoCl_2 \cdot 6H_2O$, 3; $ZnSO_4 \cdot H_2O$, 30; MoO_3, 5; $CuCl_2 \cdot 2H_2O$, 454; MgO, 590; $MnSO_4 \cdot H_2O$, 454. For Experiment II (fistulated—steer trial) it was: dicalcium phosphate 19,500; iodized salt, 17,040; KH_2PO_4, 10,200; $MnSO_4 \cdot H_2O$, 300; $FeSO_4 \cdot 7H_2O$, 600; $CuSO_4 \cdot 5H_2O$, 90; $ZnSO_4 \cdot H_2O$, 24; $CoCl_2 \cdot 6H_2O$, 1.5; MoO_3, 4.5.

[b] Equal parts by weight of ground limestone, sodium bicarbonate, magnesium carbonate and potassium carbonate.

were supplemented with stabilized vitamins A and D[3] and minerals to meet the N.R.C. requirements (1958).

The calves were weighed and measurements taken of height at withers, heart girth and body length on three consecutive days at the beginning of the experiment and at the end of each four weeks. The pH of fresh urine samples from all the heifer calves was determined on three occasions during the final three weeks of the experiment.

Experiment II. Four rumen-fistulated yearlings (two steers and two bulls) were used in an experiment employing a 4 x 4 latin square design. The composition of the rations fed is given in table 1. Before the addition of the timothy hay, the basal ration (5) contained 13.7% crude protein, 20.8% crude fiber and 2.8% ash. The analyses of rations 6 and 7 were similar except for ash which was 5.9% and 7.3% respectively. Ration 8, exclusive of the timothy hay, contained 44.1% crude protein, 6.4% crude fiber and 11.4% ash. The timothy hay was late cut and of poor quality. It contained 6.7% crude protein, 38.8% crude fiber and 4.4% ash. All

[3] Supplied through the courtesy of M. Hochberg, Nopco Chemical Co., Harrison, N. J.

rations were fortified with stabilized vitamins A and D and minerals to meet the N.R.C. requirements. The animals were fed twice each day.

The preliminary periods were at least 2 weeks and the collection periods were one week in duration. Total collections of feces and urine were made each day during the collection period and subsamples preserved for analyses. Fecal samples were dried at 75±5° C. for 24 hours and allowed to equilibriate with atmospheric moisture for at least 48 hours. The daily samples were composited for each steer and analyzed for proximate principles by standard A.O.A.C. methods. Urine samples were preserved with sodium flouride and stored in air-tight glass jars at 3° C.

On 4 days during each collection period triplicate samples of rumen fluid were taken from the posterior ventral region of the rumen for pH measurements. The samples were immediately covered with a layer of mineral oil and read on a Beckman model H2 pH meter within 5 minutes or less after being removed from the rumen. On three days of each collection period samples of rumen fluid were removed from the posterior ventral region of the rumen, strained through two layers of cheesecloth into a 200 ml. centrifuge tube which contained 4 ml. each of mineral oil and a saturated aqueous solution of mercuric chloride. The tubes were stoppered and centrifuged for 20 minutes at 2000 R.P.M. Part of the supernatent liquid was used for freezing point determinations, which were performed immediately, and part stored at 40° F. for volatile fatty acid determinations. The volatile fatty acids were determined by the method of Wiseman and Irvin (1957) as adapted for rumen liquor by Stewart (1959). The samples described above were taken 6 hours after the morning feeding.

An indication of the rate of cellulose breakdown in the rumen was obtained by using a cotton thread technique similar to that employed by Haynes (1959) which was modified from Balch and Johnson (1950). Three loops were suspended for 24 hours at each of three levels within the rumen on four days during each collection period. At the end of each collection period the total rumen and reticulum contents were removed from each animal 7 hours after feeding, weighed, mixed and sampled. Following sampling, the major part of the contents was returned to the rumen. The samples were analyzed for dry matter and ash. Water consumption was recorded during each collection period.

Results and Discussion

Experiment I.

There was considerable variation in daily feed intake on all rations both between calves and from day to day by the same calf. Calves eating at a high level would sometimes refuse feed almost completely for 1–2 days and then gradually resume eating. A similar observation was made by Reid *et al.* (1957) with sheep fed high-starch diets. They attributed the feed refusal to low rumen pH due to lactic acid fermentation.

Feed Consumption. The data for feed intakes were analyzed by the weighted squares of means procedure [4] as the calves were housed in two barns and unequal numbers of bulls and heifers were used. The weighted averages are presented in table 2.

During the first few weeks the calves did not consume the ash-supplemented ration (No. 2) as well as the other supplemented rations (Nos. 3 and 4). During the latter part of the feeding period average daily intakes improved, relative to the other rations. The unsupplemented ration (No. 1) was not consumed as well as the other rations and this difference tended to increase as the experiment progressed. The difference between the feed consumption on the basal and special-minerals-supplemented ration was

TABLE 2. WEIGHTED AVERAGE RESPONSE OF CALVES TO RATION SUPPLEMENTS—EXPERIMENT I

Supplement and ration	None 1	Alfalfa ash 2	Special minerals 3	Alfalfa hay 4	Sig. of diff.
Daily feed consumption, lb.	5.2	5.8	6.5	6.2	3>1**; 4>1*
Daily gain in weight, lb.	1.18	1.34	1.44	1.36	N.S.
Total change in height at withers, in.	2.6	3.0	3.2	3.1	3>1*
Total change in heart girth, in.	4.2	4.8	5.1	4.6	N.S.
Total change in body length, in.	4.2	4.2	4.8	5.0	4>1, 2*
Urine pH	5.88	7.91	8.07	7.24	2, 3>1*

* $P<0.05$; ** $P<0.01$; N.S.=not significant.

highly significant ($P<.01$) and that between the basal and hay-supplemented ration was significant ($P<.05$).

Growth. In general, gain in weight and changes in body measurements (table 2) were correlated with feed consumption. However, due to greater variability in the growth data, few of the differences were statistically significant. The difference between the calves on the basal and special minerals-supplement rations was significant ($P<.05$) for gain in height at withers. The other differences between these two groups approached significance in all cases. The hay-supplemented calves gained significantly more in body length than did those fed the basal or ash-supplemented rations.

Urine pH. The differences in pH of the urine (table 2) from the heifer calves fed the ash and special-mineral-supplemented rations were significantly different from that of the calves fed the unsupplemented ration. The remarkable ability of the animal to maintain the acid-base status of its tissues is well known. In this experiment it seems unlikely, from the degree of acidity of urine from calves fed the basal ration, that the neutrality regulating mechanisms of the calves were overtaxed. While the

[4] The detailed procedure was provided by C. R. Henderson, Cornell University, Ithaca, N. Y.

addition of the alkaline mineral supplements tended to improve feed consumption and rate of gain, this slight beneficial effect may be due to its buffering effect in the rumen as suggested by Matrone *et al.* (1959).

Experiment II

The animals used in Experiment II gained an average of 0.6 lb. per day. Differences between rations were not significant but gains tended to be lower on the timothy hay-soybean oil meal ration than on the corn cob-corn starch rations.

Digestibility. Data on digestibility and nitrogen retention are presented in table 3. The differences between the timothy hay ration (8) and the

TABLE 3. MEAN APPARENT DIGESTION COEFFICIENTS AND NITROGEN RETENTION—EXPERIMENT II

Supplement and ration	None 5	Low levl alfalfa ash 6	High level alfalfa ash 7	Timothy hay 8	Sig. of diff.	Coefficient of variation
						%
Dry matter	66.8	67.6	65.6	57.0	5, 6, 7>8**	3.1
Protein	76.5	77.5	75.9	69.8	5, 6, 7>8**	2.5
Crude fiber	55.9	57.3	58.3	49.2	5, 6, 7>8*	6.4
Nitrogen-free extract	70.8	71.0	69.0	61.7	5, 6, 7>8**	2.6
Ash	47.0	54.3	50.3	44.1	6>8**, 5*; 7>8*	5.8
Nitrogen retained, gm./day	37.1	39.6	39.5	13.4	5, 6, 7>8**	9.8

* $P<0.05$; ** $P<0.01$.

other rations were highly significant statistically ($P<.01$) for digestibility of dry matter, protein and nitrogen-free extract, and for nitrogen retention and significantly different ($P<.05$) for digestibility of crude fiber. The differences among rations 5, 6, and 7 were not statistically significant except for ash digestibility. Tillman *et al.* (1954a) reported that the addition of alfalfa ash to a ration containing approximately 50% prairie hay had no effect on digestibility. Similarly Bentley *et al.* (1952, 1954), feeding fattening steers low levels of mature timothy hay (1.6–2.0 lb. per head per day) with a concentrate ration composed mainly of corn and cob meal, failed to obtain an increase in digestibility when alfalfa ash or trace minerals were added. They did note an increase in feed intake and weight gain on the supplemented rations. In the present experiment the digestibility of the crude fiber of the corn cobs in the basal ration was nearly 60% which is considerably higher than other reports in the literature. It is not surprising that the alfalfa ash failed to improve this high value. This result seems to be similar to the study of Staheli and Neumann (1958) in which the addition of 2.0 lb. of alfalfa hay or its equivalent in energy, protein, or alfalfa ash did not increase the digestibility of a ration of oat

TABLE 4. AVERAGE INTRA-RUMEN ENVIRONMENT SIX HOURS AFTER MORNING FEEDING—EXPERIMENT II

Supplement and ration	None 5	Low level alfalfa ash 6	High level alfalfa ash 7	Timothy hay 8	Sig of diff.
Total VFA, meg. per 100 ml.	11.9	11.8	12.1	11.8	N.S.
Acetic in total VFA, %	66.7	68.3	68.7	67.2	7>5*
Propionic in total VFA, %	16.1	13.6	15.2	16.9	5, 8>6*
Butyric in total VFA, %	15.3	16.0	13.8	13.6	5, 6>8, 7*
Valeric[a] in total VFA, %	2.0	2.0	2.3	2.2	N.S.
Rumen pH	6.11	6.18	6.38	6.39	N.S.
Freezing point of rumen fluid, °C	−0.588	−0.594	−0.592	−0.608	N.S.
Ash in rumen ingesta, %	5.0	6.9	7.8	7.6	6, 7, 8>5**
Water in rumen ingesta, %	83.6	85.3	86.0	87.4	8>5**, 7>5*, 8>6*
Total rumen ingesta, kg.	29.1	28.3	28.6	36.7	8>5, 6, 7**
Daily ash consumption, gm.	148.	294.	335.	246.	.....
Total dry matter in rumen, kg.	4.8	4.2	4.0	4.7	N.S.
Loss of weight of cotton loops, %	16.2	21.4	22.6	27.2	8>5*
Daily water consumption, kg.	11.5	15.8	16.2	14.4	6, 7>5*
Urine, excreted, kg.	3.20	6.13	6.79	5.20	7>5**; 6, 8>5*

[a] Contained traces of unidentified higher acids.
* $P<0.05$; ** $P<0.01$; N.S.=not significant.

silage and a calcium-phosphorus mineral mixture. The digestibility of the crude fiber was 55.9 to 61.3% on their various supplements.

The data on digestibility of ash are included to show that the added ash was apparently being absorbed to a considerable extent by the animals. Presumably the extra minerals were being excreted by the kidneys since the amount of urine excreted was approximately twice as much on the ash-supplemented rations as on the basal ration (table 4).

Intra-Rumen Environment. Data on the intra-rumen environmental factors studied are given in table 4. The data for volatile fatty acids (VFA) are the averages of three samples from each animal on each ration. There were no significant differences due to rations on total VFA or on valeric acid (including some higher acids) production. The percentage of acetic acid tended to be higher and the percentage of propionic acid tended to be lower on the alfalfa ash supplemented ration than on rations 5 and 8. However, only the differences between the most extreme results were significant at the 5% level of probability. Sampling was performed 6 hours after the morning feeding. Drori (1959) fed sheep a basal diet of timothy hay and molasses supplemented with either glucose and urea, corn starch and urea, or soybean oil meal and corn meal. The acetic to propionic ratio calculated from his data on fatty acid concentrations was lowest at 1 hour after feeding and then gradually increased to twice the value by 16 hours after feeding. Five hours after feeding the value was highly significantly

greater than at 1 and 2 hours after feeding. This could explain the differences in the proportions of propionic and acetic acid observed if the ash supplementation resulted in an increased rate of fermentation so that the propionic acid production reached its peak and started to decline sooner than on the unsupplemented rations.

The differences between the rations for pH and freezing point of rumen fluid were not significant, although the difference between rations 5 and 7 for pH approached significance at the 5% level. The differences between the basal ration and all other rations were highly significant for percent of ash in rumen ingesta. For percent of water in rumen ingesta the difference between rations 5 and 8 was significant at the 1% level and that between rations 5 and 7 and between 6 and 8 at the 5% level. The difference between rations 5 and 6 approached statistical significance at the 5% level of probability. The total weight of rumen contents on ration 8 was highly significantly greater ($P<.01$) than on any of the other rations. The differences among the other rations were not significant. When the total dry matter in the rumen was calculated, the differences among the rations were not statistically significant although they were quite large. The difference between rations 5 and 7 was close to significance at the 5% level. The means of the rations are in the order in which they would be expected to fall if the ash consumption on the corn-cob ration increased the rate of digestion. Similar results were found for rate of breakdown of the cotton loops suspended in the rumen. Only the difference between rations 5 and 8 was significant statistically ($P<.05$).

The order of rate of breakdown of the cotton loops is the same as the order for digestibility of crude fiber on the corn cob rations. However, the loss of weight by the loops was greater for the timothy hay ration (8)

TABLE 5. CORRELATION COEFFICIENTS—EXPERIMENT II

Factors correlated	Correlation coefficients
Percent loss of cotton loops and daily ash intake	+.90**
Percent loss of cotton loops and pH	+.81**
Percent loss of cotton loops and percent H_2O in rumen ingesta	+.74**
Percent loss of cotton loops and H_2O consumption	+.51*
Percent loss of cotton loops and percent ash in rumen ingesta	+.49
Percent loss of cotton loops and total VFA	−.62*
Percent loss of cotton loops and total D.M. in rumen	−.63**
Percent H_2O in rumen ingesta and percent ash in rumen ingesta	+.82**
Percent H_2O in rumen ingesta and total D.M. in rumen	−.60*
Percent H_2O in rumen ingesta and pH	+.72**
H_2O consumption and daily ash intake	+.56*
Total D.M. in rumen and total VFA	+.60*
Freezing point of rumen fluid and total VFA	+.79**
pH and total VFA	+.74**
pH and percent ash in rumen ingesta	+.53*
Daily ash consumption and percent ash in rumen ingesta	+.72**

* Significant $P<0.05$; ** $P<0.01$; all others $P<.10$.

than for the corn cob rations, while the opposite situation existed for crude fiber digestibility. This is probably due to differences in the physical and chemical make up of the complex polysaccharides in the timothy hay, corn cobs and cotton thread. While the cotton loop method may not give a true quantitative picture of the digestibility of the crude fiber of a particular feedstuff being fed, it is thought to be a useful procedure as an index of the rate of microbiological activity within the rumen.

The water consumption and urine excretion followed similar trends on the various rations. Significant differences were observed between the basal ration (5) and the other rations.

Correlation Analyses. In an attempt to relate the changes in the different factors studied with one another, a number of correlation coefficients (r) were calculated. Some of these are presented in table 5.

The highest correlation coefficient obtained was between the percent loss of weight of the cotton loops and the daily ash intake. The loss of weight of the cotton loops was also significantly correlated with the percent of water and ash in the rumen ingesta and with daily water consumption. The daily water consumption was correlated with the average daily ash intake. There was a strong relationship between the percentages of water and ash in the rumen ingesta.

These data can be interpreted as showing that an increase in daily ash intake causes an increase in daily water consumption and percent ash in the rumen ingesta. These two factors result in a greater percentage of water in the rumen ingesta. In confirmation of the observation of Balch and Johnson (1950), the more fluid ingesta was associated with an increase in the rate of digestion as indicated by the 24-hr. loss of weight of cotton loops suspended in the rumen. This conclusion is further indicated by the inverse correlation between the loss of weight of the loops and the total dry matter in the rumen. Presumably the faster the rate of digestion the lower would be the total dry matter in the rumen.

A high correlation was also observed between the decrease in weight of the cotton loops and rumen pH. The pH was inversely correlated with total VFA, and directly correlated with both percent ash and the percent water in the rumen ingesta. Total VFA was highly correlated with total dry matter in the rumen and inversely related to the weight loss of the loops. These data seem to indicate that rumen pH is mainly controlled by the level of VFA present, but may be influenced by the water and ash content of the rumen ingesta.

The freezing point of rumen fluid was significantly correlated only with total VFA and pH which, as noted above, are closely related. The fact that freezing point of rumen fluid was not significantly related to water consumption, or percentage of either ash or water in the rumen ingesta suggests that most of the variability in freezing point can be attributed to variation in VFA as previously suggested by Phillipson (1942).

Summary

Two experiments were conducted to study the influence of various supplements to a low-ash ration composed mainly of corn cobs and corn starch. In the first experiment feed consumption and growth were studied and in the second experiment digestibility and intra-rumen environmental factors were studied.

The addition of a special mineral supplement composed of the carbonate or bicarbonate salts of calcium, magnesium, sodium and potassium, to a ration of corn cobs, corn starch, soybean oil meal and urea, improved feed consumption and tended to improve growth. Alfalfa hay or alfalfa ash supplements gave somewhat smaller responses that were not statistically significant in many cases. Feeding the special mineral supplement or alfalfa ash resulted in an alkaline urine while the basal ration resulted in an acid urine.

Alfalfa ash supplementation did not improve the apparent digestibility or nitrogen retention of a low-quality roughage ration composed mainly of ground corn cobs and corn starch with small amounts of timothy hay and soybean oil meal. The alfalfa ash did significantly increase the percentage of water and ash in the rumen ingesta and the daily water consumption. The results of correlation analyses indicated that the more fluid rumen ingesta were associated with an increased rate of digestion as measured by the 24-hr. loss in weight of cotton loops suspended in the rumen.

The results of the correlation analyses also indicated that rumen pH depends primarily on the concentration of volatile fatty acids but may also be influenced by the water and ash contents of the rumen ingesta. Fluctuations in freezing point of rumen fluid could be attributed primarily to variations in the volatile fatty acid content.

Literature Cited

Balch, C. C. and V. W. Johnson. 1950. Factors affecting the utilization of food by dairy cows. 2. Factors influencing the rate of breakdown of cellulose (cotton thread) in the rumen of the cow. British J. Nutr. 4:389.

Bentley, O. G. and A. L. Moxon. 1952. A semi-synthetic ration for studying the trace element requirements of cattle. J. Animal Sci. 11:756 (Abstract).

Bentley, O. G., M. Moinuddin, T. V. Hershberger, E. W. Klosterman and A. L. Moxon. 1954. The effect of trace minerals on growth performance and vitamin B_{12} synthesis of steers. J. Animal Sci. 13:789.

Burroughs, W., P. Gerlaugh and R. M. Bethke. 1950. The influence of alfalfa hay and fractions of alfalfa hay upon the digestion of ground corn cobs. J. Animal Sci. 9:207.

Chappel, C. F., R. J. Sirny, C. K. Whitehair and R. MacVicar. 1955. Effect of mineral supplements on digestibility of a corn cob ration by sheep. J. Animal Sci. 14:153.

Drori, D. 1959. Metabolic aspects of urea and carbohydrates versus plant protein for sheep. Ph.D. Thesis, Cornell University, Ithaca, N. Y.

Haynes, E. H. 1959. Ruminant digestion study techniques. 1. Cotton loops as a measure of cellulose digestion. 2. Preservation of feces to prevent nitrogen and dry matter losses. Ph.D. Thesis, Cornell University, Ithaca, N. Y.

Matrone, G., H. A. Ramsey and G. H. Wise. 1959. Effect of volatile fatty acids, sodium and potassium bicarbonate in purified diets for ruminants. Proc. Soc. Exp. Biol. and Med. 100:8.

National Academy of Sciences—National Research Council. 1958. Nutrient requirements of dairy cattle. Pub. 464.

Phillipson, A. T. 1942. The fluctuation of pH and organic acids in the rumen of the sheep. J. Exp. Biol. 19:186.

Reid, R. L., J. P. Hogan and P. K. Briggs. 1957. The effect of diet on individual volatile fatty acids in the rumen of sheep, with particular reference to the effect of low rumen pH and adaptation on high-starch diets. Australian J. Agr. Res. 8:691.

Staheli, D. L. and A. L. Neumann. 1958. The influence of alfalfa and fractions of alfalfa hay upon the digestibility of oat silage. J. Animal Sci. 17:194.

Stewart, D. G. 1959. Continuous culture as a method for studying rumen fermentation. Ph.D. Thesis, Cornell University, Ithaca, N. Y.

Swift, R. W., R. L. Cowan, G. P. Barron, K. H. Maddy and E. C. Grose. 1951. The effect of alfalfa ash upon roughage digestion in sheep. J. Animal Sci. 10:434.

Tillman, A. D., C. F. Chappel, R. J. Sirny and R. MacVicar. 1954a. The effect of alfalfa ash upon the digestibility of prairie hay by sheep. J. Animal Sci. 13:417.

Tillman, A. D., R. J. Sirny and R. MacVicar. 1954b. The effect of alfalfa ash upon the digestibility and utilization of cottonseed hulls by sheep. J. Animal Sci. 13:726.

Wiseman, H. G. and H. M. Irvin. 1957. Determination of organic acids in silage. Agr. Food Chem. 5:213.

EFFECT OF SEMEN VOLUME AND NUMBER OF SPERM ON FERTILITY AND EMBRYO SURVIVAL IN ARTIFICIALLY INSEMINATED GILTS [1, 2]

FREDERICK W. STRATMAN AND H. L. SELF [3]

University of Wisconsin, Madison [4]

THE volume of semen and number of sperm required to produce suitable fertility in artificially inseminated swine have not been definitely established. Few workers have attempted to standardize or to control the total number of sperm per insemination and, in general, the minimum total volume used per insemination has ranged from 50 ml. to over 200 ml. (Rodin and Lipatov, 1936; Lasley, 1943; Ito *et al.*, 1948; Wiggins *et al.*, 1951; Polge, 1956; Mensil du Buisson *et al.*, 1956; Aamdal and Hogset, 1957; Dziuk and Henshaw, 1958; Stratman *et al.*, 1958).

Wiggins *et al.* (1951) used various volumes of diluted fresh semen but did not standardize the number of sperm per insemination. Their data indicate that when the average number of sperm was increased from approximately 1.5×10^6 to 3.5×10^9 sperm in 50 ml. the average 3-day fertility levels were increased from zero to 91%. This latter fertility level is similar to that reported by several workers for naturally bred gilts. Recently Stratman *et al.* (1959) reported a fertility level of 58.3% in 25 gilts when 2.5×10^9 spermatozoa were inseminated in 20 ml. There is no information available, however, on fertility levels when a constant number of sperm are inseminated in different volumes, or when a constant volume has a predetermined number of sperm.

Preliminary studies (unpublished—University of Wisconsin) with fresh semen indicated that small volumes (20 ml.) in which most of the seminal fluids had been removed by centrifugation and replaced by a diluent, gave lower fertility than when an aliquot of the whole ejaculate with the same number of sperm was diluted to a greater volume (50 ml.) with the same diluent. It was not clear, however, whether the increase in fertility was a function of the increased volume *per se* or of other factors. The study to be described was designed to investigate the influence of various combinations of volume and sperm numbers on the fertilizing capacity of boar spermatozoa when diluted with the natural fluids from the boar's ejaculate.

[1] Published with the approval of the Director of the Wisconsin Experiment Station.

[2] This study was supported in part by grants from Oscar Mayer & Co., Jones Dairy Farm, Badger Breeders' Cooperative, Consolidated Breeders' Cooperative, East Central Breeders' Cooperative, Southern Wisconsin Breeders' Cooperative and by the Research Committee of the Graduate School with funds from the Wisconsin Alumni Research Foundation.

[3] Present address: Animal Husbandry Department, Iowa State University, Ames, Iowa.

[4] Department of Animal Husbandry.

Methods and Materials

Semen was obtained by means of an artificial vagina and a dummy sow from three yearling boars (a Chester White, a Landrace-Chester White and a Landrace-Chester White-Spotted Poland China) maintained in individual pens and self-fed a ration calculated to contain 16.2% crude protein, 68.0% TDN and 12.3% fiber (Stratman *et al.*, 1959). Semen was collected from each boar twice weekly at regular intervals. The semen was strained through four layers of 36 x 44 mesh gauze immediately after collection. The type of movement and the percent of motile sperm were determined for each collection as previously described (Stratman *et al.*, 1958). The percent of sperm that were motile ranged from 60.0 to 95.0 with a mean of 78.8. Type of motility ratings ranged from 5.0 to 9.0 with a mean of 7.0. The sperm concentration in the strained portion was the average of two chamber counts with a hemocytometer. The average number of sperm in the strained fresh semen was approximately 243 x 10^6 per ml. (33 samples). The quantity of fresh semen necessary to supply the total number of sperm desired was centrifuged at 1500 rpm for 6 minutes in a centrifuge with a head diameter of 27.5 cm. The exact final volume required was obtained by either removing or adding supernatant fluids. In case the original volume necessary to supply the total sperm requirements was not sufficient, another aliquot from the same collection was centrifuged at the same time to supply the necessary seminal fluid for dilution. In all cases the seminal fluid and the spermatozoa were from the same ejaculate and were approximately the same temperature when combined. Antibiotics were not used. Immediately after dilution the semen was placed in a styrene insulating container for transportation. Insemination was usually accomplished within 30 minutes after collection.

Seventy-two gilts of mixed breeding and of unknown sexual age (pre-experimental number of estrous cycles unknown) weighing 180 to 220 lb. were obtained from a local stockyard for this experiment. Only gilts appearing to be in good health and in good physical condition were used.

Gilts were held in a permanent type building and provided with an outside run where the ration (18.1% crude protein, 74.2% TDN and 6.1% fiber) shown in table 1 was fed in self-feeders. They were checked for estrus at 24-hour intervals with a vascectomized boar. A gilt was considered to be in estrus if she allowed the boar to mount. Copulation was not permitted. Insemination was accomplished with a modified plastic inseminating tube within 4 hours after estrus was detected. Loss of semen during insemination was not excessive in any case and was considered to be at random among the treatment groups.

Gilts were inseminated with a volume of either 10, 20 or 50 ml. containing either 2.5, 5.0 or 10.0 x 10^9 sperm. Gilts for each replication were assigned randomly to a volume-concentration subgroup as they exhibited estrus. Gilts were assigned alternatively to a 3-day and to a 25-day stage within each volume-concentration subgroup. They were inseminated

with semen from the boar scheduled for collection on the day they were detected in estrus, thus gilts were assumed to be assigned to boars at random and the effect of the boar on treatment was assumed to be random. Half of the gilts were slaughtered at 3 to 4 days post-breeding (3-day stage) and the other one-half was slaughtered at 25 to 29 days post-breeding (25-day stage). Each stage-volume concentration subgroup contained four replications.

The reproductive tracts were recovered after slaughter and either flushed with 0.9% saline to recover the ova or dissected to remove the embryos. Ova were examined under the stereoscopic microscope to determine if cleavage had occurred and embryos were examined for gross abnormalities

TABLE 1. COMPOSITION OF RATION
(Received by gilts *ad libitum*)

Ingredient	Pounds
Shelled corn	1100
Ground oats	300
Alfalfa meal (17%)	200
Meat scraps (50%)	200
Soybean oil meal (44%)	200
Trace mineralized salt	2
Chlortetracycline[a] (Aureomycin)	2
Zinc sulfate heptahydrate	¼
Total	2002¼

[a] Ten gm. antibiotic per lb.

or signs of degeneration. Gilts which returned to heat prior to the 25th day of gestation were not slaughtered, but were considered as having zero embryo survival.

Percent fertility is expressed as the portion of the ova recovered that exhibited normal cleavage at the 3-day stage. Percent embryo survival is expressed as the portion of the corpora lutea represented by normal embryos at the 25-day stage. Percent conception is expressed as the portion of gilts inseminated that had not returned to estrus and had one or more fertile ova or normal embryos at slaughter. Three-day litter size is expressed as the number of fertile ova recovered at slaughter while 25-day litter size is expressed as the number of normal embryos at slaughter. All percentages were transformed to angles and all data were analyzed statistically as outlined by Snedecor (1953) and Duncan (1955).

Results and Discussion

The mean percent fertility, percent embryo survival, percent conception and the litter size are shown in table 4 for the 3-day and the 25-day stages.

There were no significant differences among treatment groups in percent fertile ova at 3 days (table 2).

TABLE 2. ANALYSIS OF VARIANCE OF THE PERCENT OF RECOVERED OVA FERTILE AT 3 DAYS GESTATION

Source of variation	D.F.	M.S.
Volume	2	1531.7
Total number of sperm	2	1468.7
V x T.N.S.	4	571.1
Error	27	806.2

The 33.4% embryo survival and the 4.2 average litter size at 25-days for all gilts inseminated with 50 ml. was significantly greater than the percent survival (table 3) and the litter size for the groups inseminated with either 10 or 20 ml. of semen ($P<0.01$ and $P<0.025$). The mean survival rate of 33.4% and the 4.2 litter size in the 50-ml. groups are somewhat lower than the 52.8% and 6.6 pigs reported by Robertson *et al.*, (1951) and the 45.3% and 5.7 pigs reported by Self *et al.*, (1955) for gilts bred by natural service and fed a fattening type high protein ration similar to the ration used in the present study.

The mean percent conception rate at the 3-day stage for 10, 20 and 50 ml. of semen was 83.3, 83.3 and 91.7, respectively. These values are similar to the 90.0% value reported earlier (Stratman *et al.*, 1958) for a 50-ml. volume, but they are slightly lower than the 100.0% reported by Wiggins *et al.* (1951) for 50-ml. of diluted semen. The mean percent conception rate for 10, 20 and 50 ml. at the 25-day stage was 8.3, 8.3, 50.0, respectively, with the 50-ml. group being significantly greater than the 10- and 20-ml. groups ($P<0.05$).

Considering only those pregnant at 25 days post-breeding, the 8.5 mean embryo litter size for the three pregnant gilts (3 of 4) in the 50-ml. groups is greater than the 5.0 embryos in each of the single pregnant gilts in the 10- and 20-ml. groups, respectively.

Only one of the four gilts inseminated with 50-ml. of semen containing 5.0×10^9 sperm and killed at 25 days gestation was pregnant. The other three gilts had not returned to estrus and did not have any embryos at slaughter (two at 25 days, one at 29 days). All three gilts, however, exhibited discrete areas of vascularization in the uterine endometrium at autopsy indicating that death of the embryos had probably occurred after

TABLE 3. ANALYSIS OF VARIANCE OF THE PERCENT SURVIVAL OF EMBRYOS TO THE 25TH DAY OF GESTATION

Source of variation	D.F.	M.S.
Volume	2	2578.2**
Total number of sperm	2	422.6
V x T.N.S.	4	415.1
Error	27	464.7

** Significant at the .01 level of probability.

TABLE 4. FERTILITY, EMBRYO SURVIVAL, CONCEPTION RATE, AND LITTER SIZE AT 3-DAYS AND AT 25-DAYS GESTATION BY TREATMENT GROUPS

Volume	Sperm insemminated X 10^9	Gilts per stage	Fertility at 3-days	Embyro survival at 25-days	Conception rate		Litter size			
							3-Days		25-Days	
					3-Days	25-Days	All gilts	Pregnant gilts only	All gilts	Pregnant gilts only
ml.			%	%	%	%				
	2.5	4	36.9	0.0	75.0	0.0	5.0	6.7	0.0	0.0
10.0	5.0	4	59.6	0.0	75.0	0.0	7.2	9.7	0.0	0.0
	10.0	4	56.7	12.5	100.0	25.0	5.2	5.2	1.2	5.0
	2.5	4	49.6	0.0	75.0	0.0	6.5	8.7	0.0	0.0
20.0	5.0	4	15.8	9.6	75.0	25.0	2.0	2.7	1.2	5.0
	10.0	4	60.6	0.0	100.0	0.0	7.0	7.0	0.0	0.0
	2.5	4	71.4	32.8	100.0	50.0	6.2	6.2	4.5	9.0
50.0	5.0	4	44.8	17.3	75.0	25.0	5.5	7.3	2.2	9.0
	10.0	4	87.8	50.0	100.0	75.0	9.8	9.8	6.0	8.0
				Totals and Averages						
10.0		12	51.1	4.2	83.3	8.3	5.8	7.2	0.4	5.0
20.0		12	42.1	3.2	83.3	8.3	5.2	6.1	0.4	5.0
50.0		12	68.0	33.4	91.7	50.0	7.2	7.8	4.2	8.5
	2.5	12	52.6	10.6	83.3	16.6	5.9	7.2	1.5	9.0
	5.0	12	40.1	9.0	75.0	16.6	4.9	6.6	1.1	7.0
	10.0	12	68.4	20.8	100.0	33.3	7.3	7.3	2.4	6.5

placentation had begun. The presence of small follicles indicated that ovarian activity had been initiated prior to slaughter.

There were no significant differences among the groups of gilts in the 3-day stage in ovulation or in ova recovery rates. The mean ova recovery rate of 88.3% is slightly higher than the 78.9%, 80.3%, 86.0% ova recovery rate reported by Hauser *et al.* (1952), Squiers *et al.* (1952) and Baker *et al.* (1954), respectively.

The relatively uniform mean fertility levels of the 10, 20 and 50 ml. volume groups at the 3-day stage and the highly significant differences in embyro survival and litter size at 25-days seems to indicate one of two possibilities. Either with the techniques used it was not possible to distinguish normal from abnormally developing ova at the 3-day stage, or there was a higher rate of embryo motality occurring when the smaller volumes of semen were used. Increasing the total number of spermatozoa per insemination from 2.5×10^9 to 10.0×10^9 did not cause a significantly different effect at either the 3-day or 25-day stage. Thus, it appears that within the limits of this experiment, volume had a greater influence on embryo survival to 25 days gestation than did the total number of sperm. There was a tendency, however, for 10×10^9 sperm to give better results than either 2.5×10^9 or 5.0×10^9. At the same time 2.5×10^9 tended to be better than 5.0×10^9, thus the data on numbers of sperm are inconclusive.

The large volume of semen ejaculated by the boar during natural service suggests that volume may play an important role in the process of conception and embryo survival. The exact volume needed for the sow or gilt is not known; but, it does appear from this study that at least 50-ml. of semen are required to obtain suitable fertility, conception, and survival to the 25th day when gilts are inseminated artificially.

The mode of action by which volume may exert a beneficial influence on litter size at 25 days is not clear; however, one possibility is that distention by a larger volume may stretch the uterine myometrium and initiate a contractile response which assists in sperm transport to assure that sperm are present in sufficient quantities at the site of fertilization at the proper time. A second possibility is the initiation of a neurogenic stimulus sufficient to trigger the release of substances from the neurohypophysis. Observations on one sow, whose pigs had been weaned at 3 days of age and had returned to estrus 6 days later, showed that mounting (without copulation) by a vasectomized boar elicited milk "let down" as evidenced by milk streaming from the teats. Cervical stimulation during copulation would appear to be another possibility. Oxytocin has been associated with increased uterine motility and the facilitation of sperm transport in the bovine (Van Demark and Hays, 1953, 1955; Van Demark and Moeller, 1951) and with a beneficial effect in the 3-day fertility level in gilts (Stratman *et al.*, 1959). Oxytocin has also been sugested as the neurohumoral stimulator of LTH (prolactin) secretion in the rat. (Benson and Folley, 1956, 1957; Desclin, 1956). Uterine dilation in the rabbit at term

brought about increased contractility only if the pituitary (oxytocin) was present (Ferguson, 1941) but this could not be substantiated in the estrogenized rabbit uterus (Cross, 1958) indicating a possible species or reproductive stage interaction.

Mechanical distention of the ovine uterus increased the release of FSH and/or LH and possibly LTH (prolactin) to accelerate the rate of follicle maturation and ovulation (Moore and Nalbandov, 1953). The swine ovum loses its ability to be fertilized within 48 hours after ovulation and 24 hours is the maximum survival time for the boar sperm in the female reproductive tract (Lewis, 1911). Blandau and Young (1939) showed that increasing the time from ovulation to fertilization of the guinea pig ovum decreased its ability to survive as a normal developing fetus. Thus the multiple ovulations of the sow may be hastened and synchronized and embryo survival increased by any factor which would evoke the release of FSH and/or LH and bring the sperm and ova together when both are more viable.

The possibility that some of the constituents of the seminal fluids are helpful in conditioning the uterus for improved placentation and survival of the embryos cannot be ruled out at this time.

Summary

Seventy-two gilts of mixed breeding were artificially inseminated with either 10, 20, or 50 ml. of semen containing either 2.5, 5.0 or 10.0 billion sperm. One-half of the gilts were slaughtered at 3 days post-breeding, the other one-half at 25 days post-breeding. Percent fertility, percent embryo survival, 3- and 25-day post-breeding litter size and conception rates were determined. There were no significant differences among treatments in fertility or litter size at 3 days. At 25 days the group inseminated with 50-ml. volume had a higher rate of embryo survival ($P<0.01$) and percent conception ($P<0.05$) than the 10 or 20 ml. volume regardless of the number of sperm used. There was no significant effect of total numbers of sperm inseminated although there did appear to be an improvement with a greater number of sperm.

Literature Cited

Aamadal, J. and I. Hogset. 1957. Artificial insemination in swine. J. Am. Vet. Med. Assn. 131:59.

Baker, L. N., L. C. Ulberg, R. H. Grummer and L. E. Casida. 1954. Inhibition of heat by progesterone and its effect on subsequent fertility in gilts. J. Animal Sci. 13:648.

Blandau, R. J. and W. C. Young. 1939. The effects of delayed fertilization on the development of the guinea pig ovum. Am. J. Anat. 64:303.

Benson, G. K. and S. J. Folley. 1956. Oxytocin as a stimulator for the release of prolactin from the anterior pituitary. Nature 177:700.

Benson, G. K. and S. J. Folley. 1957. The effect of oxytocin on the mammary gland involution in the rat. J. Endocr. 16:189.

Cross, B. H. 1958. The motility and reactivity of the oestrogenized rabbit uterus, *in vivo*, with comparative observation on milk ejections. J. Endocr. 16:237.

Desclin, T. 1956. Hypothalmus et Liberation d'Hormone luteatrophique. Experiences de Greffe hypophysaire chez le Rat hypophysectomize. Action luteotrophique de l'Oxytocine. Ann. Endocr. Paris. 17:586.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 2:1.

Dziuk, P. J. and G. Henshaw. 1958. Fertility of boar semen artificially inseminated following *in vitro* storage. J. Animal Sci. 17:554.

Ferguson, J. K. W. 1941. Study of motility of the intact uterus at term. Surg. Gynec. Obstet. 73:359.

Hauser, E. R., G. E. Dickerson and D. T. Mayer. 1952. Reproductive development and performance of inbred and crossbred boars. Mo. Agr. Exp. Stat. Res. Bul. 264.

Ito, S., T. Niwa, A. Kudo and A. Mizuho. 1948. Studies on the artificial insemination in swine. Res. Bul. 55, Zootec. Exp. Stat., Chiba, Japan.

Lewis, L. L. 1911. The vitality of reproductive cells. Okla. Agr. Exp. Stat. Bul. No. 96, pp. 3–97.

Lasley, J. F. 1943. Artificial insemination of swine and storage of boar semen. Univ. of Mo., Master Thesis. (Cited in Mo. Agr. Exp. Stat. Bul. 461).

Mensil du Buisson, F. Du and L. Dauzier. 1956. Donness Experimentales our L'Insemination Naturelle et Artificialle de la Trius. Proc. 3rd Int. Cong. Animal Reprod. (Camb.) 3:62.

Moore, W. W. and A. V. Nalbandov. 1953. Neurogenic effects of uterine distention on the estrous cycle of the ewe. Endocr. 53:1.

Polge, C. 1956. Artificial insemination in pigs. Vet. Rec. 68:62.

Rodin, L. M. and V. I. Lipatov. 1936. Artificial insemination of sows. Probl. Zivota. 9:108. (Cited in Animal Breeding Abst. 4:205).

Robertson, G. L., L. E. Casida, R. H. Grummer and A. B. Chapman. 1951. Some feeding and management factors affecting age at puberty and related phenomena in Chester White and Poland China gilts. J. Animal Sci. 10:841.

Self, H. L., R. H. Grummer and L. E. Casida. 1955. The effects of various sequences of full and limited feeding on the reproductive phenomena in Chester White and Poland China gilts. J. Animal Sci. 14:573.

Snedecor, G. W. 1953. Statistical Methods (4th ed.). Iowa State College Press, Ames, Iowa.

Squiers, C. D., G. E. Dickerson and D. T. Mayer. 1952. Influence of inbreeding, age and growth rate of sows on sexual maturity, rate of ovulation, fertilization and embryonic survival. Mo. Agr. Exp. Stat. Res. Bul. 494.

Stratman, F. W., H. L. Self and V. R. Smith. 1958. Fertilization rates obtained with boar semen stored for zero and twelve hours. J. Animal Sci. 17:598.

Stratman, F. W., H. L. Self and V. R. Smith. 1959. The effect of oxytocin on fertility in gilts artificially inseminated with a low sperm concentration and semen volume. J. Animal Sci. 18:634.

Van Demark, N. L. and R. L. Hayes. 1953. Motility patterns in the female reproductive tract. Iowa State College J. Sci. 28:107.

Van Demark, N. L. and R. L. Hays. 1955. Sperm transport in the perfused genital tract of the cow. Am. J. Physiol. 183:510.

Van Demark, N. L. and A. N. Moeller. 1951. Speed of spermatozoan transport in the reproductive tract of the estrous cow. Am. J. Physiol. 165:674.

Wiggins, E. L., R. H. Grummer and L. E. Casida. 1951. Minimal volume of semen and number of sperm for fertility in artificial insemination in swine. J. Animal Sci. 10:138.

INCREASED FEEDLOT BLOAT FROM FEEDING SOYBEAN OIL IN A MIXED RATION TO STEERS[1]

C. J. Elam, J. Gutierrez and R. E. Davis[2]

U. S. Department of Agriculture[3]

BLOAT is one of the leading metabolic disorders in ruminants in the United States and results in a loss of millions of dollars annually. Pasture bloat is a greater problem to the livestock industry than feedlot bloat, but the latter contributes substantially to the overall loss due to bloat (Ensminger *et al.*, 1955).

Various vegetable oils and animal fats have been used successfully in the prevention and treatment of pasture bloat. A partial list includes lard oil (Brown *et al.*, 1958; Johnson *et al.*, 1958), tallow (Flynn, 1957; Erwin *et al.*, 1957; Reid and Johns, 1957; Colvin *et al.*, 1959), lecithin (Johnson *et al.*, 1958), peanut oil (Johns, 1954; Reid and Johns, 1957; Southcott *et al.*, 1958), groundnut oil (Flynn, 1957), olive oil (Johns, 1954; Reid and Johns, 1957), corn oil (Colvin *et al.*, 1959), and soybean oil (Johns, 1954; Reid and Johns, 1957; Brown *et al.*, 1958; Johnson *et al.*, 1958).

Relatively little research has been reported on feedlot bloat. Smith et al. (1953) compounded a ration that caused a high incidence of bloat, and it has been used by several investigators in studying experimental feedlot bloat (Lindahl and Davis, 1955; Lindahl *et al.*, 1957; Jacobson *et al.*, 1957; Jacobson *et al.*, 1958; Gutierrez *et al.*, 1959). Lindahl and Davis (1955) reported that giving corn oil by drench to cattle fed this ration had no effect on feedlot bloat. Brown *et al.* (1958) found that adding a water dispersible oil to the drinking water had little effect on the occurrence of feedlot bloat in steers. However, the incidence of bloat was low in their experiment, making any conclusions questionable.

The present study was initiated to investigate some of the effects of mixing crude degummed soybean oil into a feedlot bloat-producing ration fed to steers under two feeding regimens.

Experimental Procedure

Preliminary Period. Thirty Hereford steers averaging 578 lb. were randomly divided into two groups of 15 steers each and full-fed individually a feedlot bloat-producing ration composed of: ground barley, 61%; dehydrated alfalfa, 22%; soybean oil meal, 16% and NaCl, 1%. The feeds were ground, mixed, and made into ⅜-inch pellets. Fifteen steers received

[1] Presented in part before the 51st Annual Meeting of the American Society of Animal Production, Chicago, Illinois, November 27, 1959.

[2] The authors wish to thank Steven Hoyt and Eddie Riddle for technical assistance and G. Beattie, T. C. Humphrey, C. W. Lowman and D. L. Thompson for care of the experimental animals.

[3] Beef Cattle Research Branch, AHRD, ARS, ARC, Beltsville, Md.

TABLE 1. DESCRIPTION OF BLOAT RATINGS

Rating	Description
1	No bloat—no distention or very slight distention only.
2	Mild—mild, but definite distention on left side.
3	Moderate—marked distention on left side and full on right side.
4	Severe—balloon-like, distended on both sides.

feed twice-a-day (between 5:30–7:30 a.m. and 3:00–4:30 p.m.) and 15 were allowed to eat *ad libitum*. All steers were in individual stalls except between the hours of 7:30–10:00 a.m. and 1:00–3:00 p.m. each day when they were exercised outside in a dirt lot. Water and a mineral supplement were available in the exercise lot. Steers were rated for bloat at 7:00 a.m. and 4:30 p.m. daily during the 105-day preliminary period. Table 1 describes the numerical bloat ratings. By using a stomach tube, ruminal samples were taken prior to the start of the experiment, when all steers were fed a high roughage ration, and periodically during the preliminary period. Samples were collected between 8:00 and 8:45 a.m. and were taken immediately to the laboratory. Sub-samples were analyzed for ingesta volume increase (IVI) and stable IVI by the method of Jacobson *et al.* (1957) and pH was determined with a glass electrode. Observations on bacterial and protozoal populations were made on slides from ruminal samples with a phase microscope. Ruminal fluid, obtained by straining the ingesta through four layers of cheesecloth, was acidified, frozen, and later analyzed for volatile fatty acids (Neish, 1949).

Experimental Period. After 105 days, each group was divided into three subgroups of five steers each so that the average bloat ratings by groups were similar. One group was continued on the basal ration described earlier, the second received the basal ration with 4% crude degummed soybean oil replacing 4% barley by weight, and the third group was fed soybean oil at 8% of the ration. The chemical composition of the rations is shown in table 2. The steers remained on the same feeding schedules used during the preliminary period. Bloat ratings were made on each steer at 7:00 and 7:30 a.m. and 4:00 and 4:30 p.m. daily. Ruminal samples were taken during the 4th and 14th weeks of the 15-week experimental period and analyzed as described above.

TABLE 2. PERCENTAGE COMPOSITION OF EXPERIMENTAL RATIONS

Ration description	Control	4% Soybean oil	8% Soybean oil
Moisture	10.70	8.98	8.96
Crude protein	16.88	16.24	15.48
Ether extract	2.87	7.02	10.65
Crude fiber	9.54	9.36	8.89
Ash	4.72	5.20	4.97
N.F.E.	55.29	53.20	51.05

Results

Preliminary Period. The first case of bloat was observed on the 12th day and during the first 30 days about 80% of the steers had bloated at least once and many were bloating consistently. There were 896 cases of bloat in the group fed twice-a-day or 30% of the number possible if every steer had bloated twice daily. One steer in this group died on the 50th day of the experiment; although the cause was not determined definitely, bloat was suspected. In the *ad lib.* group, 617 cases of bloat resulted which amounted to 20% of the number possible. The average bloat ratings (bloat indices) during this period, 1.37 and 1.24, respectively, were not significantly different, statistically. The low ratings resulted from averaging all animals, including those not bloated.

Bloat incidence increased with time during the preliminary period. There was a 23% incidence of bloat between days 45 and 75, while the mean incidence was 42% during the next 30 days. Lindahl *et al.* (1957) also reported an increase in feedlot bloat with time.

Results of volatile fatty acid analyses are shown in figure 1. A marked

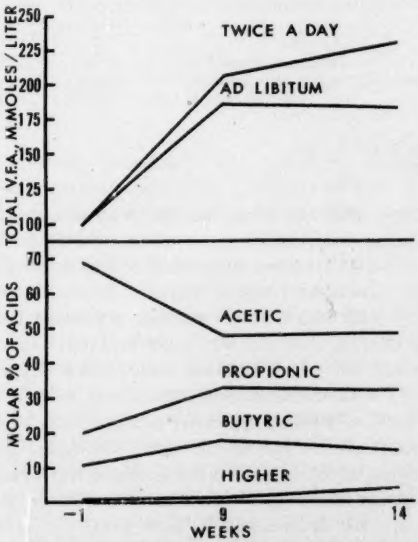

Figure 1. The concentration and proportions of ruminal volatile fatty acids during the preliminary period as affected by the bloat producing ration. Steers were fed a ration of 89% mixed hay plus protein supplement, salt and bonemeal before start of preliminary period (—1 week).

increase in total concentration of fatty acids in the ruminal fluid resulted from feeding the bloat-producing ration. Furthermore, the concentration was higher for steers fed twice-a-day than for those allowed to eat *ad libitum* ($P<.05$). It should be noted that all steers were sampled at the same time of day.

The molar percentage of acetic acid decreased greatly from feeding the bloat-producing ration while the percentages of propionic and butyric acids increased. There was little change in the percentage of the higher acids. Since there was no difference between groups in the percentage of the individual acids, the average of all steers is shown in figure 1. Neither the total concentration nor the percentage of the fatty acids was highly correlated with the bloat score. A correlation coefficient of —.31 between

TABLE 3. FEEDLOT BLOAT IN STEERS FED SOYBEAN OIL DURING THE EXPERIMENTAL PERIOD

	Experimental period			
Bloat index during preliminary period	Treatment[a]	Total cases[d]	Percentage incidence[d]	Bloat index[d]
1.45	Control[b]	795	38	1.50
1.49	4% soybean oil[c]	1170	61	1.81
1.45	8% soybean oil	1690	80	2.13

[a] Figures represent 10 steers per treatment.
[b] One steer died on day 91.
[c] Two steers died (day 54 and day 66).
[d] Statistically significant at $P<.01$.

percentage propionic acid and bloat was the highest correlation observed, but was not significant statistically.

The IVI and stable IVI values were variable and were not highly correlated with bloat. However, ruminal samples from bloated steers were consistently foamy with small, stable bubbles predominating.

The pH of the ruminal samples was not correlated ($r=.03$) with bloat ratings. The average pH of all ruminal samples was 5.2 and was highly correlated ($r=.82$) with the total concentration of volatile fatty acids.

Experimental Period. Table 3 summarizes the results during the period of feeding soybean oil in the rations. A highly significant increase in bloat resulted from feeding soybean oil and the increase was linear with increasing oil levels. Average incidence of bloat for the control, 4% oil, and 8% oil treatment groups was 38, 61, and 80%, respectively. Bloat incidence in the control groups was comparable to the average of all steers during the last month of the preliminary period. Furthermore, the increased incidence of bloat with time observed in the preliminary period was not evident during the experimental period. Apparently, the plateau, or potential for bloat, on the basal ration had been reached during the earlier phase of the study.

As in the preliminary period, there was more bloat among the steers fed twice-a-day than among those allowed to eat *ad libitum* but the difference was not statistically significant. On the other hand, when the data from both periods were combined, making a total of 210 days, there was significantly ($P<.05$) more bloat in the group of steers fed twice-a-day.

Three steers fed twice-a-day died during the oil feeding period. All three had been consistent bloaters. Two fed the 4% soybean oil ration died during the night and the cause could not be determined. The third steer was on the basal ration and died from bloat.

The results of physical and chemical measurements on the ruminal samples are shown in table 4. Ingesta volume increase was not altered by feeding soybean oil, but stable IVI was significantly ($P<.01$) greater

TABLE 4. INFLUENCE OF FEEDING SOYBEAN OIL DURING EXPERIMENTAL PERIOD ON VARIOUS RUMEN TRAITS [a]

Treatment	IVI	Stable IVI [b]	pH	Molar percentage volatile fatty acids				Total VFA conc. m moles/l.
				C_5+	C_4	C_3	C_2	
Control	37	13	5.5	5.6	16.7	29.5	48.2	176
4% soybean oil	37	21	5.4	5.6	15.4	29.6	49.4	168
8% soybean oil	30	23	5.8	3.7	13.6	30.9	51.8	147

[a] Each figure represents an average of two samplings from each of 10 steers per treatment, except two steers in 4% soybean oil group which were sampled once only.
[b] Significant at level of $P<.01$.

for steers receiving oil. Bloat score and stable IVI were positively correlated between groups, but the within group correlation was low ($r=.28$). This indicates that the stable IVI value was limited as an index of feedlot bloat in this experiment.

Ruminal pH, as measured in this experiment, was not affected by soybean oil in the ration (table 4) nor was it correlated with bloat.

Neither the proportions nor the total concentrations of the ruminal volatile fatty acids were changed significantly by feeding soybean oil. Furthermore, the average values during the oil-feeding phase were similar to those found during the preliminary period (figure 1) when no oil was fed. Individual or total fatty acids were not highly correlated with bloat.

The highest correlation with bloat found within groups during the experimental period was between the proportion of acetic acid and bloat ($r=.24$). The correlation between propionic acid and bloat during this period was $-.03$ compared to $-.31$ during the preliminary period.

Gram-stained slides of ruminal samples which had been diluted 1:10 were prepared, and observations made on the microbial population changes which occurred with the onset of bloat symptoms. Gross changes in the ruminal bacterial population before and during the onset of bloat agreed with the bacterial changes described by Gutierrez *et al.* (1959). The most distinctive and easily detectable change in the early stages of bloat develop-

ment was an increase in the number of large, long-chained streptococci. In addition, some bloaters showed a predominance of gram positive rods which were subsequently isolated from the ruminal ingesta samples and will be described in a separate publication.

The ruminal samples from the bloated animals were examined also for changes in the protozoal population during the development of bloat. Normal populations of the ruminal protozoal genera *Isotricha, Dasytricha, Entodinium* and *Diplodinium* were seen in all samples taken from the animals before bloat occurred. Microscopic examination of samples taken during bloat showed no correlation between the presence or absence of any of the rumen protozoa and the occurrence of the bloat symptoms, although in the later stages of the feeding trials the protozoa disappeared in some of the animals. The death of the protozoa in these instances was attributed to the increased acidity which takes place in the rumen when large amounts of carbohydrate are fed (Hungate *et al.*, 1952).

Discussion

The increased occurrence of bloat among steers fed soybean oil in their ration is in contrast to the prophylactic and therapeutic effects of soybean oil reported for pasture bloat (Johns, 1954; Reid and Johns, 1957; Brown *et al.*, 1958; Johnson *et al.*, 1958). This result indicates that feedlot bloat and pasture bloat should not be considered identical, even though a frothy ruminal ingesta may exist in both cases.

The various traits measured in the ruminal contents do not reveal a ready explanation for the increased bloat in oil-fed steers. Although stable IVI was significantly higher for steers fed the oil, the low correlation between bloat and stable IVI would not allow one to place emphasis on this trait. The increased foam stability, as suggested by the stable IVI values, was unexpected since oils have generally been effective in decreasing foam stability. Brethour *et al.* (1958) reported an accumulation of frothy foam in the rumen of sheep fed corn oil.

Perhaps soybean oil mixed with the feed served as a readily available substrate for microbial attack. The polysaccharide capsular material produced by bacteria associated with feedlot bloat (Gutierrez *et al.*, 1959) together with the rapid gas production would provide a condition similar to that described by Head (1959) as predisposing to foam formation. Such an explanation would be in accordance with the "slime theory" advanced by Hungate *et al.* (1955) and Jacobson and Lindahl (1955) for pasture and feedlot bloat, respectively.

It seems possible that other oils, perhaps those less susceptible to microbial attack, might give different results from soybean oil. Of course, it is possible that soybean oil administered differently or at other levels might also show a different effect. The oil levels used in the present study were selected arbitrarily.

Average daily gain and pounds feed consumed daily by steers fed 0, 4, and 8% oil ration were 1.44, 13.4; 1.14, 11.9; and 0.80, 11.3, respectively. These differences were not significant statistically since a great deal of variation existed within groups. The addition of soybean oil to the rations tended to decrease feed consumption, but the results are confounded by the increased bloat in the oil groups so that conclusions regarding feed consumption are limited. In some cases steers continued to bloat consistently even after their feed consumption had decreased. However, the severity of bloat did appear to be related to quantity of feed consumed by bloating steers. Excessive and rapid feed consumption by steers, that had consistently bloated mildly to moderately, resulted in several instances in severe bloat.

Increased bloat in steers fed twice-a-day, compared to *ad libitum*, may have resulted from the rapid consumption of feed by these steers. By periodically weighing residual feed in the troughs of the *ad libitum* group for several days, it was found that on the average they consumed less feed during short periods of time than the steers fed twice-a-day. Steers in the latter group usually ate rapidly for a short period of time after feed was placed before them. However, it is possible that some cases of bloat in the *ad libitum* group were not detected since bloat scores were made at specified times, while feed was available all the time.

Ruminal fatty acid values were similar to those reported by Jacobson *et al.* (1958). The marked decrease in the molar proportion of acetic acid and increase in propionic and butyric acids from feeding the bloat-producing ration was typical of the response expected when readily available carbohydrates are fed to ruminants. There were only small differences between average fatty acid values obtained at different times while the steers were fed the bloat-producing ration. Conversely, Jacobson *et al.* (1958) reported a significant increase in the proportion of acetic acid and a concomitant decrease in propionic acid between the 11th and 16th weeks of feeding.

The low correlations between rumen traits and bloat agree with the results reported by Jacobson *et al.* (1958). In calculating the correlation coefficients, the bloat index used was an average of the bloat ratings given a steer on the mornings samples were collected. There were only slight differences between these coefficients and those in which the bloat index for the entire experimental period was used. Time of sampling the ruminal ingesta may be a factor in the low correlations found between bloat and various rumen traits. The collection of samples at 1 to 1½ hr. after feeding, when bloat was usually at a maximum, instead of at about 3 hr. might have revealed other differences.

Summary

Thirty steers were used to study some of the factors involved in the development of feedlot bloat. During a 105-day preliminary period, the

steers received a bloat-producing ration in order to determine their bloat potential or susceptibility. Steers were then divided into outcome groups and allocated into three equal groups of ten steers each on the basis of bloat history. One group was continued on the basal bloat-producing ration, the second was fed the basal ration with 4% soybean oil replacing an equal weight of grain, and the third group received the basal ration with 8% soybean oil. These treatments continued for an additional period of 105 days.

Feeding soybean oil resulted in a highly significant increase in feedlot bloat. Furthermore, there was a greater incidence of bloat among steers fed twice-a-day than among those allowed to eat *ad libitum*. Out of several rumen traits studied during the experiment, only the stable ingesta volume was increased significantly by feeding soybean oil. None of the ruminal volatile fatty acids was highly correlated with bloat. Observations on ruminal microorganisms suggested a relationship between the presence of certain ruminal bacteria and feedlot bloat.

Literature Cited

Brethour, J. R., R. J. Sirny and A. D. Tillman. 1958. Further studies concerning the effects of fats in sheep rations. J. Animal Sci. 17:171.

Brown, L. R., R. H. Johnson, N. L. Jacobson and P. G. Homeyer. 1958. Effects of administration of oils and of penicillin on incidence and severity of bloat and certain other responses of cattle. J. Animal Sci. 17:374.

Colvin, Jr., H. W., J. M. Boda and T. Wegner. 1959. Studies on the experimental production and prevention of bloat in cattle. III. The effect of vegetable oil and animal fat on acute legume bloat. J. Dairy Sci. 42:333.

Ensminger, M. E., M. W. Galgan and W. L. Slocum. 1955. Problems and practices of American cattlemen. Wash. Agr. Exp. Stat. Bul. 562.

Erwin, E. S., C. B. Roubicek, L. Rosenblatt and F. Pritchard. 1957. The influence of tallow on the incidence and severity of cattle bloat. Rpt. Fourth Conf. Rumen Function, A.R.S., U.S.D.A., Maryland Hotel, Chicago, Ill.

Flynn, K. E. 1957. Spraying to control bloat. J. Agr. Victoria 55:577.

Gutierrez, J., R. E. Davis, I. L. Lindahl and E. J. Warwick. 1959. Bacterial changes in the rumen during the onset of feed-lot bloat of cattle and characteristics of *Peptostreptococcus elsdenii* n. sp. Appl. Microbiol. 7:16.

Head, M. J. 1959. Bloat in cattle. Nature 183:757.

Hungate, R. E., R. W. Dougherty, M. P. Bryant and R. M. Cello. 1952. Microbiological and physiological changes associated with acute indigestion in sheep. Cornell Vet. 42:423.

Hungate, R. E., D. W. Fletcher, R. W. Dougherty and B. F. Barrentine. 1955. Microbiol activity in the bovine rumen: Its measurements and relation to bloat. Appl. Microbiol. 3:161.

Jacobson, D. R. and I. L. Lindahl. 1955. Studies on biochemical, physical and bacteriological factors involved in feed lot bloat. Md. Univ. Agr. Exp. Stat. Misc. Publ. 238, p. 9.

Jacobson, D. R., I. L. Lindahl, J. J. McNeill, J. C. Shaw, R. N. Doetsch and R. E. Davis. 1957. Feedlot bloat studies. II. Physical factors involved in the etiology of frothy bloat. J. Animal Sci. 16:515.

Jacobson, D. R., I. L. Lindahl, J. J. McNeill, J. C. Shaw, R. N. Doetsch and R. E. Davis. 1958. Feedlot bloat studies. III. Rumen fatty acids and metabolic activity

of rumen bacteria of animals placed on a bloat-producting diet. J. Animal Sci. 17:304.

Johns, A. T. 1954. Bloat in cattle on red clover. I. New Zealand J. Sci. and Tech. 36:289.

Johnson, R. H., L. R. Brown, N. L. Jacobson and P. G. Homeyer. 1958. Effectiveness and practicability of some oils, penicillin, m-decyl alcohol, and lecithin in the control of alfalfa bloat. J. Animal Sci. 17:893.

Lindahl, I. L. and R. E. Davis. 1955. Prevention and management of bloat in the feedlot. Rpt. Third Conf.—Rumen Function, A.R.S., U.S.D.A., Maryland Hotel, Chicago, Ill.

Lindahl, I. L., R. E. Davis, D. R. Jacobson and J. C. Shaw. 1957. Feedlot bloat studies. I. Animal and dietary factors. J. Animal Sci. 16:165.

Neish, A. C. 1949. Production and properties of 2, 3-butanediol. Determination of the fermentation acids by partition chromatograph. Canadian J. Res. 27B:6.

Reid, C. S. W. and A. T. Johns. 1957. Bloat in cattle on red clover. III. Treatment and prevention with anti-foaming agents. New Zealand J. Sci. and Tech. 38:908.

Smith, C. K., J. R. Brunner, C. F. Huffman and C. W. Duncan. 1953. Experimental production of frothy bloat in cattle. J. Animal Sci. 12:932.

Southcott, W. H. and R. W. Hewetson. 1958. Investigation on the use of peanut oil in bloat control. Australian Vet. J. 34:136.

STUDIES WITH THE CELLULOLYTIC FRACTION OF RUMEN BACTERIA OBTAINED BY DIFFERENTIAL CENTRIFUGATION [1, 2]

BURK A. DEHORITY, KHALED EL-SHAZLY [3] AND RONALD R. JOHNSON

Ohio Agricultural Experiment Station,[4] *Wooster*

THE digestion of cellulose by rumen micro-organisms *in vitro* was first studied in detail by Marston in 1948. Since that time investigators have studied forage, cellulose, starch and protein digestion, nutritional requirements and volatile fatty acid production of rumen bacteria *in vitro;* however, the techniques employed have been variable (Gray *et al.,* 1951; Burroughs *et al.,* 1950; Huhtanen *et al.,* 1954; Bentley *et al.,* 1954; Cheng *et al.,* 1955).

Workers in this laboratory have been studying the nutritional requirements of the cellulose-digesting bacteria, using the *in vitro* technique described by Bentley *et al.* (1955). Briefly, this technique involves separation of the bacteria from rumen liquor by centrifugation in the Sharples supercentrifuge, resuspending the bacteria in buffer and using this suspension as an inoculum in a purified basal medium. Slight modifications of this basic method were reported by Dehority *et al.* (1957). In addition, a method for obtaining the bacteria from pressed rumen ingesta with phosphate buffer has been recently described by Johnson *et al.* (1958). Further work, however, indicated that a large carry-over of non-cellulolytic bacteria in the inoculum reduced the sensitivity of this technique for studying the nutritional requirements of the cellulolytic bacteria.

The present paper describes a differential centrifugation method whereby a fraction of rumen bacteria can be obtained which contains primarily the cellulolytic bacteria. Microscopic examination, end products of cellulose digestion and the nutritional requirements of this fraction of rumen bacteria are also reported.

Experimental

In Vitro Technique. The basic method for the *in vitro* fermentations was similar to that described by Bentley *et al.* (1955). The basal fermentation medium, however, was changed to include those modifications suggested by Dehority *et al.* (1957). For these studies glucose was omitted from the

[1] Approved for publication as Journal Article No. 86–59 by the Associate Director of the Ohio Agricultural Experiment Station. A report of this work was presented at the annual meeting of the American Society of Animal Production, November 27–28, 1959.

[2] This work was supported in part by funds allocated to the Station on the recommendation of the North Central Technical Committee on Factors Affecting Utilization of Feed by Ruminants (NC–25).

[3] On leave from the Faculty of Agriculture, University of Alexandria, Alexandria, Egypt.

[4] Department of Animal Science.

basal medium. Digestion of cellulose was determined according to the method of Hershberger *et al.* (1955).

Differential Centrifugation. The bacteria were obtained by washing pressed rumen ingesta with phosphate buffer as described by Johnson *et al.* (1958). The rumen bacteria were separated into various fractions by the scheme shown in figure 1.[5] Centrifugation at 250 x G and 1500 x G was carried out with an International centrifuge, size 2, fitted with an 8-place head and 50-ml. lusteroid tubes. Centrifugation at 3000 x G was done in 80-ml. lusteroid tubes in a Servall type "SP" angle centrifuge. Fifty

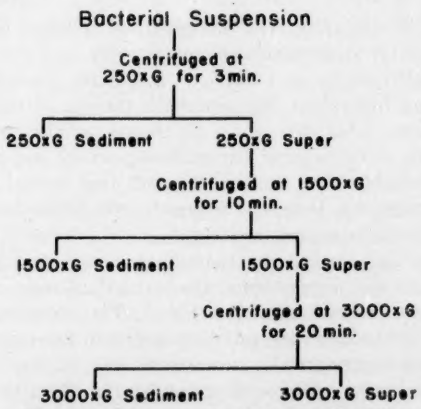

Figure 1. Diagramatic scheme of the differential centrifugation technique used to separate rumen bacteria.

ml. of the bacterial suspension were placed in each tube, centrifuged, and the supernatant[6] liquid decanted into another tube for the next centrifugation. In those cases where the sediment was not packed extremely hard in the bottom of the tube, care was taken not to transfer any of the sediment into the next higher fraction. The sediments were suspended in phosphate buffer prior to inoculation of the fermentation flasks. All supernatants and sediments were added at a level equivalent to 40 ml. of the original bacterial suspension.

Bacterial Protein. Trichloroacetic acid (TCA) insoluble nitrogen was used as an estimate of bacterial protein. The method of analysis has been previously described by Cline *et al.* (1958).

End Product Analysis. The contents of the fermentation flasks, after incubation, were analyzed for free acids. A silicic acid column method,

[5] The times of centrifugation given in figure 1 were maintained in all of the studies reported, including recentrifugation to obtain washed inoculums.

[6] Supernatant refers to the liquid above the packed sediment.

similar to that described by Bulen *et al.* (1952), was used. However, mixtures of benzene-butanol, instead of chloroform-butanol were used as eluants (Linke, 1952). In addition, alcohol analyses were carried out according to the method of Friedemann (1938).

Microscopic Examination. The various fractions obtained by differential centrifugation were examined microscopically before and after the fermentation period. The Gram-stain (Hucker modification) was used for all of these preparations.

Results and Discussion

Differential Centrifugation. The milligrams of cellulose digested by the different fractions of steer rumen microorganisms and the milligrams of TCA insoluble nitrogen in each fraction (inoculum) are given in table 1. The ratio of these two values thus represents the mg. of cellulose digested per mg. of TCA insoluble nitrogen in the inoculum. The amounts of TCA insoluble nitrogen in the original bacterial suspension, and in the 250 x G sediment are probably high because of small feed particles, which were detected microscopically. However, figures for the remaining fractions are good estimates of bacterial protein nitrogen.

Cellulose digestion by the supernatants indicates that the cellyloytic rumen bacteria are still in suspension after centrifugation at 1500 x G, but are predominantly sedimented at 3000 x G. The sediments obtained at 250 x G and 1500 x G gave some cellulose digestion; however, the 3000 x G sediment digested approximately as much cellulose as the original suspension. As discussed later, cellulose digestion by the 250 x G and 1500 x G sediments appears to be carried out by the same organisms as occur predominantly in the 3000 x G sediment.

TABLE 1. CELLULOSE DIGESTION BY VARIOUS FRACTIONS OF STEER RUMEN MICRO-ORGANISMS OBTAINED BY DIFFERENTIAL CENTRIFUGATION

Fraction (Inoculum)	Cellulose digested, mg.		Mean TCA[b] insoluble nitrogen in inoculum, mg.	Ratio of cellulose digested to TCA insoluble nitrogen
	Range	Mean[a]		
Whole suspension	1140–1246	1175± 39[c]	16.90	69.5
250 x G, Supernatant	1126–1326	1258± 80	10.17	123.7
1500 x G, Supernatant	1246–1380	1324± 56	7.27	182.1
3000 x G, Supernatant	0– 684	183±296	1.83	100.0
250 x G, Sediment	577– 898	717±118	5.52	130.1
1500 x G, Sediment	604– 817	713± 94	2.71	256.4
3000 x G, Sediment	992–1514	1157±233	3.65	317.0

[a] Mean of six determinations.
[b] Trichloroacetic acid (TCA).
[c] Standard deviation.

TABLE 2. CELLULOSE DIGESTION BY VARIOUS FRACTIONS OF SHEEP RUMEN MICRO-ORGANISMS OBTAINED BY DIFFERENTIAL CENTRIFUGATION

Fraction (Inoculum)	Cellulose digested, mg.		Mean TCA[b] insoluble nitrogen in inoculum, mg.	Ratio of cellulose digested to TCA insoluble nitrogen
	Range	Mean[a]		
Whole suspension	1032–1313	1119±131[c]	19.35	57.8
250 x G, Supernatant	1085–1286	1189± 82	11.50	103.5
1500 x G, Supernatant	1045–1326	1189±144	5.30	224.3
3000 x G, Supernatant	0	0	1.20	0
250 x G, Sediment	564– 845	711±141	5.62	126.3
1500 x G, Sediment	711–1005	858±155	5.02	171.0
3000 x G, Sediment	831–1085	955±135	3.42	279.2

[a] Mean of four determinations.
[b] Trichloroacetic acid (TCA).
[c] Standard deviation.

As the cellulolytic bacteria fraction became more purified the ratio of cellulose digested to TCA insoluble nitrogen increased. Of the supernatants, the 1500 x G supernatant gave the highest digestion per mg. of nitrogen. Cellulose digestion with the sediments increased markedly from the 250 x G sediment up to the 3000 x G sediment. If the 250 x G supernatant is relatively free of feed particles, as implied earlier, and the TCA insoluble nitrogen is a good estimate of bacterial protein, then it may be concluded that the bacterial protein of the 250 x G supernatant is approximately three times that of the 3000 x G sediment (see table 1). And, since both fractions digested about the same amount of cellulose in 30 hours, this means that approximately two-thirds of the total bacteria of the 250 x G supernatant have been removed by centrifugation without a reduction in cellulose digesting activity.

A similar separation of rumen organisms was performed with ingesta obtained from sheep. Rumen ingesta was removed from two fistulated sheep with a pair of tongs, pressed to remove the liquid, and the residue washed with phosphate buffer, as described earlier, to obtain the bacterial suspensions. As shown in table 2, results obtained with these suspensions were similar to those obtained with the bovine bacterial suspensions.

Microscopic Examination. Photomicrographs (x600) of the micro-organisms in the various sediments are shown in figure 2. Figure 2 (A) shows that the 250 x G sediment consisted primarily of large bacteria and feed particles; however, a number of smaller bacteria are attached to the feed particles and are thus sedimented with this fraction. Examination of the media after fermentation of cellulose with this inoculum revealed a proliferation of the Gram-negative micrococci which were "attached to" or closely associated with the feed particles.

The 1500 x G sediment, shown in figure 2 (B), consists of a very few large bacteria, an abundance of the medium size bacteria and some of the smaller bacteria. As with the 250 x G sediment, the Gram-negative micrococcus proliferated when this inoculum was allowed to ferment cellulose.

Examination of the 3000 x G sediment, figure 2 (C), reveals that this fraction consists primarily of the small bacteria. After fermentation for 30 hours with cellulose as the sole energy source, the flora shown in figure 2 (D) was obtained. The bacteria shown in figure 2 (D) are principally Gram-negative micrococci, and a few thin Gram-negative rods. These Gram-negative micrococci are anaerobic, coccoid to slightly oval, and about 0.6 micron in diameter; they generally occur singly. These bacteria are present in the 3000 x G sediment in large numbers, which suggests that they are one of the principal types of cellulose-digesting organisms in the rumen. In another study in this laboratory, in which sheep were fed purified wood cellulose, the Gram-negative micrococci were observed to proliferate *in vivo* (el-Shazly *et al.*, 1959).

Based on the above observations, it can be concluded that the Gram-negative micrococci are the principal cellulose-digesting bacteria which proliferate *in vitro*. These bacteria were also found in large numbers in

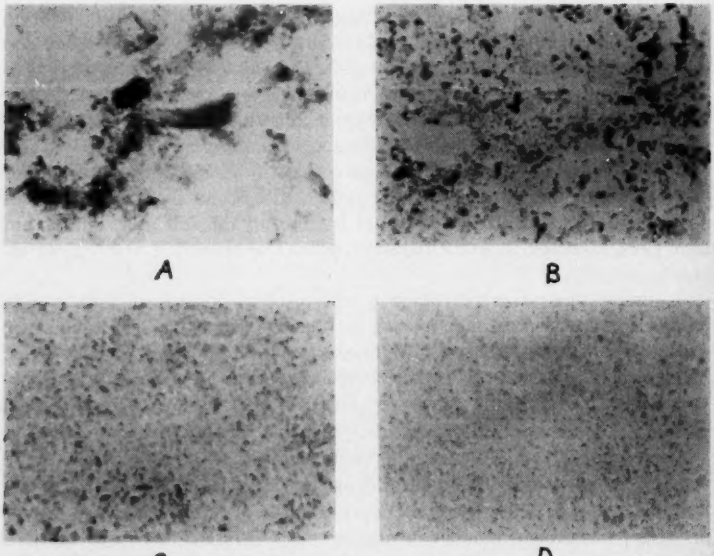

Figure 2. Photomicrographs (x600) of the various sediments obtained by differential centrifugation. A. 250 x G sediment; B. 1500 x G sediment; C. 3000 x G sediment; D. 3000 x G sediment after incubation for 30 hours with cellulose as the sole carbohydrate.

the rumen of the donor animals fed a mixed hay diet. Apparently cellulose digestion by the 250 x G sediment occurs because these micrococci are attached to feed particles and are sedimented with that fraction. These bacteria also appear to be responsible for the cellulose digestion by the 1500 x G sediment. The high ratio of cellulose digested to mg. TCA insoluble nitrogen (bacterial protein) indicates the 3000 x G sediment to be the more highly purified cellulolytic culture.

End Products of Cellulose Digestion. To investigate the end products produced by the fermentation of cellulose, flasks were inoculated with the 3000 x G sediment obtained from suspensions of both steer and sheep rumen bacteria, with cellulose as the sole carbohydrate source, and analyzed for organic acids after 30 hours incubation (table 3). The major

TABLE 3. ORGANIC ACID END PRODUCTS OF CELLULOSE FERMENTATION BY THE 3000 x G SEDIMENT *IN VITRO*

	Milliequivalents of acid per 100 ml.	
Acid	Steer[a]	Sheep[b]
Butyric and higher	0.25	0.37
Propionic	2.89	3.22
Acetic	2.93	2.36
Formic	....	0.26
Succinic	1.14	0.14

[a] Average of four fermentations.
[b] Average of two fermentations.

end products were acetic and propionic acids. Since valeric acid is contained in the basal medium as a growth factor, it probably comprises a portion of the "butyric and higher" fraction. Some succinic acid was found in the media after cellulose fermentation by both steer and sheep bacteria, while formic acid, on the other hand, was found only when sheep bacteria were used as the inoculum. The possibility exists however, that succinic acid may be an important end product of cellulose fermentation, and that this is fermented to the volatile fatty acids by contaminating organims in the cellulolytic culture. Preliminary experiments, in which the cellulolytic culture was propagated into a new flask after the original 30-hour fermentation, indicate a decrease in propionic acid and an increase in succinic acid as compared with the steer data in table 3. Further work is needed to clarify this point.

Analysis of the cellulose fermentation media for volatile alcohols revealed only trace amounts. Apparently they are not end products of cellulose digestion by this culture, but, if formed, are further metabolized.

Nutritional Requirements. Bentley *et al.* (1955) found that rumen microorganisms required the presence of certain volatile fatty acids, particularly valeric acid, for the digestion of cellulose *in vitro*. Since valeric was also found in greater concentration than the other active acids in rumen

juice, it has been routinely included in the basal media. Both biotin and p-aminobenzoic acid (PABA) were found to be required in the basal medium for maximum cellulose digestion with added valeric acid (Bentley *et al.*, 1955); however, fermentations without added biotin, PABA or valeric acid digested 0.2 to 0.3 gm. of cellulose, indicating their carry-over in the inoculum. The requirement for these factors by the cellulolytic micro-organisms used in the present study is presented in table 4. The data obtained with the unwashed inoculum (3000 x G sediment) indicate that neither biotin and PABA together or valeric acid alone enhances

TABLE 4. STUDIES ON THE NUTRITIONAL REQUIREMENTS OF THE CELLULOLYTIC FRACTION (3000 x G SEDIMENT) OF RUMEN BACTERIA

	Unwashed inoculum [b]		Washed inoculum [c]	
Additions to basal medium [a]	Cellulose digested, gm.	Increase in TCA insoluble nitrogen, mg.	Cellulose digested, gm.	Increase in TCA insoluble nitrogen, mg.
Biotin and PABA [d]	0.00	5.8	0.00	2.2
Valeric Acid (V.A.)	0.18	15.3	0.00	4.9
Biotin and V.A.	0.79	16.9	0.71	16.6
PABA and V.A.	0.70	16.2	0.03	7.5
Biotin, PBA and V.A.	1.06	18.8	0.63	18.4

[a] Basal medium consisted of minerals, urea and cellulose.
[b] Average of four experiments.
[c] Average of two experiments.
[d] Para-aminobenzoic acid (PABA).

cellulose digestion to a very marked degree. Either one or both of the vitamins added in combination with valeric acid, however, produced a definite increase in cellulose digestion. The increase in TCA insoluble nitrogen produced by valeric acid alone in the absence of added biotin and PABA indicates a carry-over of these vitamins in the inoculum.

To test the possible carry-over of B-vitamins, the 3000 x G sediment was washed by resuspending it in phosphate buffer and recentrifuging at 3000 x G. Results obtained with this washed inoculum (table 4) show that valeric acid alone had no effect on cellulose digestion, and that it increased TCA insoluble nitrogen only slightly, as compared to the increase it produced with the unwashed inoculum. The data indicate that a combination of biotin and valeric acid is required for cellulose digestion, and that the requirement for PABA is secondary.

Figure 3 shows cellulose digestion and increase in bacterial protein by the washed 3000 x G sediment in the presence of increasing amounts of biotin. From these data the requirement for biotin appears to be 0.5γ per 100 ml.

When increasing levels of PABA (0 to 50γ/100 ml.) were added to the basal media containing biotin and valeric acid, cellulose digestion was 1.32 gm. without added PABA and 1.36 when 50γ PABA were added. Further

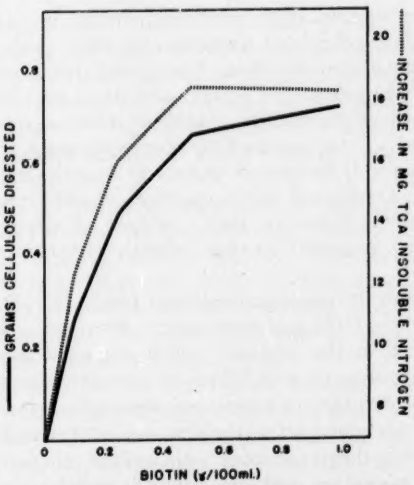

Figure 3. Cellulose digestion and the increase in trichloroacetic acid (TCA) insoluble nitrogen of the washed 3000 x G sediment in response to added biotin.

work with two anti-metabolites of PABA (2-chloro-PABA and sulfanilamide) also failed to demonstrate any requirement of these bacteria for PABA.

As shown in table 4, washed cells digested less cellulose than unwashed cells, when all the known nutrients were included in the basal media. At first, it was thought that this extra handling required in washing the cells killed a portion of the inoculum. However, when autoclaved rumen fluid supernatant (obtained from a Sharples' Supercentrifuge) was added to the washed cell fermentations, cellulose digestibility returned to the same value as obtained with the unwashed inoculum. This suggested the presence of an additional nutritional requirement by the cellulolytic bacteria, which was not included in the basal medium and is partially removed by the washing procedure. Work is now underway in this laboratory to identify this nutrient.

As mentioned above, Bentley *et al.* (1955) found valeric acid to be the most active of the volatile fatty acids which enhanced the digestion of cellulose by rumen bacteria *in vitro*. However, Bryant and Doetsch (1955), working with cultures of *Bacteroides succinogenes* (a cellulose digesting organism isolated from the rumen) reported that this organism required a combination of a branched-chain fatty acid (iso-butyric, iso-valeric or DL-α-methyl-n-butyric acid) and a straight chain acid (valeric or caproic acid) for growth on a purified medium. More recently, Allison *et al.* (1958)

investigated the volatile fatty acid requirements of several strains of *Ruminococcus flavefaciens* and *Ruminococcus albus*, both anaerobic cellulolytic cocci isolated from the rumen. They found that a mixture of acetate, isobutyrate and the valeric acid isomers and also a mixture of acetate and isovalerate greatly stimulated the growth of these organisms. Because of these varied reports of the volatile fatty acid requirement of different rumen cellulolytic bacteria, it became of interest to investigate this requirement with the 3000 x G sediment micro-organisms. Table 5 gives the data obtained when valeric, isobutyric and a mixture of valeric and isobutyric acids were tested as growth factors, cellulose digestion being used as a criterion.

The results with the unwashed inoculum (table 5) indicate that valeric acid can satisfy the fatty acid requirement. However, a slight amount of cellulose digestion in the negative control suggested possible carry-over of a small amount of an iso-acid. When the inoculum was analyzed for total volatile fatty acids only trace amounts were found, indicating that the amount of iso-acids added in the inoculum would be minute. The same type of experiment was then conducted with washed cells as an inoculum to reduce possible carry-over, and essentially the same results were obtained. It appears that the presence of isobutyric acid enhances the effect of valeric

TABLE 5. EFFECT OF VALERIC, ISOBUTYRIC AND A MIXTURE OF VALERIC AND ISOBUTYRIC ACIDS ON CELLULOSE DIGESTION BY THE CELLULOLYTIC FRACTION (3000 x G SEDIMENT) OF RUMEN BACTERIA

Acid added to basal medium	Total conc. of acid, mg./100 ml.	Cellulose digested, gm.	
		Unwashed cells[a]	Washed cells
None	...	0.18	0.00
Valeric	2.5	0.36	....
	5.0	....	0.26
	7.5	0.78	....
	15.0	0.92	0.68
	25.0	0.90	0.76
Isobutyric	2.5	0.24	....
	5.0	....	0.18
	7.5	0.26	....
	15.0	0.43	0.11
	25.0	0.35	0.20
Valeric plus isobutyric[b]	2.5	0.37	....
	5.0	....	0.24
	7.5	0.66	....
	15.0	0.91	0.67
	25.0	0.90	0.76

[a] Average of two experiments.
[b] The mixture consisted of equal parts of each acid.

acid, since, for example, the 15.0 mg. level of the mixture was more effective than 7.5 mg. of valeric acid alone. However, as mentioned earlier, the presence of the iso-acid does not appear to be required. One must keep in mind the possibility that a contaminant organism in the culture could be synthesizing an iso-acid, or releasing branched-chain amino acids into the medium through cellular breakdown, which could be converted to iso-acids (Dehority *et al.*, 1958).

In view of the results, the authors conclude that the cellulolytic organisms cultured in these *in vitro* studies correspond closely with both *Ruminobacter parvum*, described by Sijpesteijn (1948), and *Ruminococcus albus*, described more recently by Hungate (1957). However, an exacting comparison with *Ruminobacter parvum* is difficult because both Sijpesteijn's and our cultures were not pure. Morphologically both organisms appear to be very similar to those found in the present study.

Sijpesteijn reported that the main acids produced were acetic and propionic, along with traces of butyric acid and small amounts of non-volatile organic acids. This composition approximates that found in the present study (table 3). Sijpesteijn also reported that *Ruminobacter parvum* requires rumen fluid factors for satisfactory growth. Based on the present study and other reports on isolation of rumen fluid factors (Bentley *et al.*, 1955; Bryant and Doetsch, 1955; Allison *et al.*, 1958), this factor or one of these factors is probably the volatile fatty acids. Thus, the valeric acid requirement of the organisms used in these studies would further justify the comparison with *Ruminobacter parvum*.

More exacting data are available on *Ruminococcus albus* because this organism has been isolated in pure culture. Hungate (1957) reports that *Ruminococcus albus* produces ethanol, acetic acid, formic acid and lactic acid, but no succinic acid, from the fermentation of cellulose. Thus a marked difference appears to exist between *Ruminococcus albus* and the present organisms as far as end products of cellulose digestion are concerned. In addition, as mentioned earlier, Allison *et al.* (1958) found that *Ruminococcus albus* required a mixture of acetate and isovalerate for growth; whereas, the volatile fatty acid requirement of the organism in the present study can be satisfied by valeric acid.

Summary

Suspensions of bovine and ovine rumen bacteria were separated into several different fractions by means of differential centrifugation. That fraction of bacteria still in suspension at 1500 x G but sedimented at 3000 x G was found to contain the majority of the cellulolytic rumen bacteria. This fraction contained only 21% of the TCA insoluble nitrogen (bacterial protein) found in the whole suspension of rumen microorganisms.

Photomicrographs are shown of the bacteria in the various fractions. Fermentation studies with the 3000 x G sediment showed that after incuba-

tion with cellulose as the sole carbohydrate source, a predominance of Gram-negative micrococci were present along with a lesser number of very small Gram-negative rods. These observations indicate that the Gram-negative micrococci are the principal cellulose-digesting organisms which proliferate *in vitro*. These same organisms were also found in large numbers in the inoculum obtained from the rumen.

Incubation of the 3000 x G sediment with cellulose as the sole carbohydrate substrate resulted in the formation of large amounts of acetic and propionic acid, a lesser amount of succinic acid and traces of butyric and higher acids. The microorganisms showed a strict requirement for both valeric acid and biotin. Further studies showed that the fatty acid requirement could be satisfied by valeric acid, and that a branched-chain acid was not required.

Literature Cited

Allison, M. J. and M. P. Bryant. 1958. Volatile fatty acid growth factor for cellulolytic cocci of bovine rumen. Science 128:474.

Bentley, O. G., R. R. Johnson, S. Vanecko and C. H. Hunt. 1954. Studies on factors needed by rumen microorganisms for cellulose digestion *in vitro*. J. Animal Sci. 13:581.

Bentley, O. G., R. R. Johnson, T. V. Hershberger, J. H. Cline and A. L. Moxon. 1955. Cellulolytic-factor activity of certain short-chain fatty acids for rumen microorganisms *in vitro*. J. Nutr. 57:389.

Bryant, M. P. and R. N. Doetsch. 1955. Factors necessary for the growth of *Bacteroides succinogenes* in the volatile acid fraction of rumen fluid. J. Dairy Sci. 38:340.

Burroughs, W., N. A. Frank, P. Gerlaugh and R. M. Bethke. 1950. Preliminary observations upon factors influencing cellulose digestion by rumen microorganisms. J. Nutr. 40:9.

Bulen, W. A., J. E. Varner and R. C. Burrell. 1952. Separation of organic acids from plant tissues. Anal. Chem. 24:187.

Cheng, E. W., G. Hall and W. Burroughs. 1955. A method for the study of cellulose digestion by washed suspensions of rumen microorganisms. J. Dairy Sci. 38:1225.

Cline, J. H., T. V. Hershberger and O. G. Bentley. 1958. Utilization and/or synthesis of valeric acid during the digestion of glucose, starch and cellulose by rumen microorganisms *in vitro*. J. Animal Sci. 17:284.

Dehority, B. A., O. G. Bentley, R. R. Johnson and A. L. Moxon. 1957. Isolation and identification of compounds from autolyzed yeast, alfalfa meal and casein hydroylsate with cellulolytic factor activity for rumen microorganisms *in vitro*. J. Animal Sci. 16:502.

Dehority, B. A., R. R. Johnson, O. G. Bentley and A. L. Moxon. 1958. Studies on the metabolism of valine, proline, leucine and isoleucine by rumen microorganisms *in vitro*. Arch. Biochem. Biophys. 78:15.

Friedemann, T. E. 1938. The identification and quantitative determination of volatile alcohols and acids. J. Biol. Chem. 123:161.

Gray, F. V., A. F. Pilgrim and R. A. Weller. 1951. Fermentation in the rumen of the sheep. I. The production of volatile fatty acids and methane during the fermentation of wheaten hay and lucerne hay *in vitro* by microorganisms from the rumen. J. Exp. Biol. 28:74.

Hershberger, T. V., O. G. Bentley and A. L. Moxon. 1955. A rapid volumetric method for the determination of cellulose in studies with rumen microorganisms *in vitro*. J. Animal Sci. 14:725.

Huhtanen, C. N., R. K. Saunders and L. S. Gall. 1954. Fiber digestion using the miniature artificial rumen. J. Dairy Sci. 37:328.

Hungate, R. E. 1957. Microorganisms in the rumen of cattle fed a constant ration. Can. J. Microbiol. 3:289.

Johnson, R. R., B. A. Dehority and O. G. Bentley. 1958. Studies on the *in vitro* rumen procedure: Improved inoculum preparation and the effects of volatile fatty acids on cellulose digestion. J. Animal Sci. 17:841.

Linke, E. G. 1952. Chromatographic separation of volatile fatty acids produced in the artificial rumen. M.S. Thesis, The Ohio State University.

Marston, H. R. 1948. The fermentation of cellulose *in vitro* by organisms from the rumen of sheep. Biochem. J. 42:564.

el-Shazly, K., R. R. Johnson and B. A. Dehority. 1959. Biochemical and microscopical comparison between *in vivo* and *in vitro* rumen fermentations. J. Animal Sci. 18:1518 (Abstract).

Sijpesteijn, A. K. 1948. Cellulose-decomposing bacteria from the rumen of cattle. Ph.D. Thesis, Leiden.

EFFECT OF FEEDING TRANQUILIZERS TO GROWING AND FINISHING SWINE

R. A. PICKETT, J. H. CONRAD AND W. M. BEESON

Purdue University Agricultural Experiment Station,[1, 2] *Lafayette, Indiana*

IN the past few years, several feeding trials have been conducted with tranquilizing agents added to the rations of growing and finishing cattle and sheep. Results of these trials have varied, but it has been shown that these additives may increase daily rate of gain and improve feed efficiency in ruminant animals (Beeson *et al.*, 1958; Sherman *et al.*, 1958; Sherman *et al.*, 1959).

This study was initiated to determine the effect of several tranquilizers on growth rate and feed efficiency of growing-finishing swine.

Experimental Procedure

Trial 1. Seventy-two weanling Durocs were allotted to six groups according to sex, weight and litter with each lot containing six gilts and six barrows. The pigs were allowed *ad libitum* a complete mixed ration on alfalfa-ladino clover pasture with each group on a one-acre plot. The ration consisted of 84 parts ground yellow corn and 16 parts protein supplement to provide a 14% crude protein ration for the pigs up to a weight of 100 lb. From a weight of 100 lb. to 200 lb., the pigs in each lot received a 12% crude protein ration of 90 parts ground yellow corn and 10 parts protein supplement. The protein supplement had the following composition: soybean meal (44%) 47.5; meat and bone scraps (50%) 40.0; dehydrated alfalfa meal (17%) 10.0; and iodized salt, 2.0. It was fortified to supply 300 parts per million zinc and the following levels of vitamins per ton of supplement—folic acid, 0.3 gm.; riboflavin, 10 gm.; pantothenic acid, 20 gm.; niacin, 45 gm.; choline chloride, 50 gm. and B_{12}, 50 mg. Twenty grams of antibiotics consisting of 5 gm. chlortetracycline, 2.5 gm. penicillin, 5 gm. oxytetracycline, and 7.5 gm. zinc bacitracin were also added to each ton of complete mixed feed.

Five tranquilizers, representing four chemical types of tranquilizing agents, were fed in this experiment. The treatments and the levels added per pound of ration were as follows: Lot I, control; Lot II, 60 mcg. reserpine (a Rauwolfia alkaloid); Lot III, 25 mg. *Rauwolfia vomitoria* (a Rauwolfia alkaloid); Lot IV, 25 mg. meprobamate (a substituted propanediol); Lot V, 0.5 mg. hydroxyzine (a diphenyl methane derivative); and, Lot VI, 0.5 mg. perphenazine (a phenothiazine derivative).

[1] Contribution from the Department of Animal Science, Journal Paper No. 1587.

[2] Supported in part by a grant from Ciba Pharmaceutical Products, Inc. Summit, New Jersey. Tranquilizers were furnished by Chas. Pfizer and Co., Inc., Wallace Laboratory and the Schering Corporation.

Trial 2. Sixty weanling Duroc pigs were allotted to six groups according to sex, weight and litter. These pigs were allowed *ad libitum* a complete mixed ration, and each group was confined to a concrete pen 30 ft. by 40 ft. which also contained a Pur-Dual hog house 10 ft. by 12 ft. The basal ration was similar to that of trial 1, the crude protein being 16% until the average lot weight of the pigs was 100 lb. and 14% thereafter to 200 lb. Vitamins A and D were added to the ration during this trial.

Five tranquilizers, reserpine, trifluomeprazine, perphenazine, hydroxyzine and tetrahydrozoline were fed. The level of tranquilizer was adjusted

TABLE 1. TRANQUILIZER LEVEL PER TWO-WEEK PERIOD. TRIAL 2

Two-week period	1	2	3	4	5	6	7
Tranquilizer							
Lot I—Control	....	....	....	....	....	....	....
Lot II—Reserpine	0.1[a]	0.2	0.3	0.4	0.3	0.3	0.3
	0.2[b]	0.6	1.3	2.2	2.0	2.3	2.7
Lot III—Trifluomeprazine	0.5[a]	1.0	1.5	2.0	1.5	1.5	1.5
	0.8[b]	2.7	6.2	10.5	9.3	11.3	13.1
Lot IV—Perphenazine	1.0[a]	2.0	3.0	4.0	5.0	5.0	5.0
	1.9[b]	6.7	13.1	22.8	32.5	37.2	38.3
Lot V—Hydroxyzine	1.0[a]	2.0	3.0	4.0	5.0	5.0	5.0
	1.9[b]	6.5	13.2	25.1	37.3	38.3	44.9
Lot VI—Tetrahydrozoline	5.0[a]	10.0	15.0	20.0	10.0	5.0	5.0
	9.8[b]	34.4	63.9	104.4	61.4	33.5	40.9

[a] Mg. per pound of ration.
[b] Average mg. per pig per day.

every two weeks according to the pigs' performance and during the two-week feeding periods (table 1).

In both trials results were summarized when the first of the six lots reached an average weight of 200 lb. Gain data were treated statistically by analysis of variance as outlined by Snedecor (1956).

Results and Discussion

Trial 1. At the levels fed, reserpine, *Rauwolfia vomitoria,* meprobamate, hydroxyzine or perphenazine had no significant effect on daily rate of gain when compared to the control. Feed consumption was not markedly affected by the tranquilizers, and feed conversion was fairly uniform for all lots (table 2). None of the pigs showed any signs of sedation.

Baird and McCampbell (1959) fed hydroxyzine at 0.25 mg. per lb. of feed in combination with a stilbestrol implant or with added tallow and did not obtain significant differences in rate of gain.

Trial 2. The addition of reserpine (Lot II) to the ration at levels up to 0.3 mg. per lb. of feed had no effect on feed intake, feed conversion or

TABLE 2. RESULTS OF FEEDING VARIOUS TRANQUILIZERS TO SWINE ON PASTURE. TRIAL 1

(May 21 to September 3, 1958—105 Days)

Lot number	I	II	III	IV	V	VI
Tranquilizer per pound of feed[a]	Control	Reserpine 60 mcg./lb.	Rauwolfia 25 mg./lb.	Meprobamate 25 mg./lb.	Hydroxyzine 0.5 mg./lb.	Perphenazine 0.5 mg./lb.
No. pigs per lot[b]	12	11	12	10	10	10
Av. initial wt., lb.	28	28	23	28	28	23
Av. final wt., lb.	197	186	207	191	193	200
Total gain, lb.[c]	169	158	174	163	165	172
Av. daily gain, lb.	1.61	1.51	1.66	1.55	1.57	1.64
Av. daily feed, lb.	4.90	4.79	4.90	5.00	4.70	5.10
Feed per lb. gain, lb.	3.04	3.18	2.95	3.23	2.99	3.11
Av. daily tranquilizer	0	287 mcg.	12? mg	125 mg.	2.35 mg.	2.55 mg.
Range of tranquilizer daily	0	93–454 mcg.	35–18? mg.	40–180 mg.	0.73–4.03 mg.	0.7–3.86 mg.

[a] Reserpine and *Rauwolfia vomitoria* were fed at equivalent levels of reserpine activity.
[b] Seven pigs removed due to virus pneumonia.
[c] Least significant mean difference—$P<0.05=15.25$ lb.

rate of gain, while 0.4 mg. tended to depress these performance factors. Returning the reserpine level to 0.3 mg. resulted in performance which paralleled that of the control pigs.

Trifluomeprazine (Lot III) at 2.0 mg. per lb. of feed depressed feed intake and average daily gain. However, the effect was not observed with 1.5 mg. at which level the pigs appeared calmer than the controls.

Perphenazine (Lot IV) appeared to make the pigs less active as the level reached 4.0 and 5.0 mg. per lb. of feed. Feed consumption was reduced with a resulting decrease in rate of gain. These pigs were fed the 5.0 mg. level for the last six weeks of the experiment, and their rate of gain remained about 0.2 lb. per day below the controls during that time.

TABLE 3. RESULTS OF FEEDING VARIOUS LEVELS OF TRANQUILIZERS TO SWINE IN DRYLOT. TRIAL 2

(November 4, 1958 to February 10, 1959—98 Days)

Lot number	I	II	III	IV	V	VI
Tranquilizer per pound of feed	Control	Reserpine 0.1–.4 mg.	Tri-fluomeprazine 0.5–2.0 mg.	Perphena-zine 1–5 mg.	Hy-droxvzine 1–5 mg.	Tetrahydrozo-line 5–20 mg.
No. pigs per lot	10	9	10	10	10	10
Av. initial weight, lb.	37	37	37	37	37	37
Av. final weight, lb.	201	196	188	192	204	191
Total gain, lb.[a]	164	159	151	155	167	154
Av. daily gain, lb.	1.68	1.62	1.54	1.58	1.71	1.57
Av. daily feed, lb.	5.57	5.48	5.18	5.27	5.70	5.13
Feed per lb. gain, lb.	3.32	3.38	3.36	3.34	3.33	3.26

[a] Least significant mean difference—$P<.01=9.6$ lb.; $P<.05=7.2$ lb.

Hydroxyzine (Lot V) did not appear to affect performance when fed at levels up to 5.0 mg. per lb. of feed. There were no signs of sedation, and the pigs gained slightly faster than the controls.

Tetrahydrozoline at the level of 20 mg. per lb. of feed caused a reduction in feed intake and a reduced rate of gain which continued until the level was reduced.

The pigs receiving trifluomeprazine, perphenazine or tetrahydrozoline gained at a significantly slower rate ($P<.01$) than the controls at the conclusion of the experiment (table 3). This slower rate of gain appeared to be due to reduced feed intake as the feed conversion was very similar for all six lots, varying from 326 to 338 lb. of feed required per 100 lb. of gain.

Summary

The levels of reserpine, *Rauwolfia vomitoria*, meprobamate, hydroxyzine and perphenazine fed in the first trial, which was conducted on alfalfa-ladino clover pasture, did not affect the behavior or performance of the pigs. In the second trial, conducted in drylot, each lot received varying levels of reserpine, trifluomeprazine, perphenazine, hydroxyzine or tetra-

hydrozoline. At the lower levels, none of the tranquilizers had an apparent effect; but the incorporation of reserpine, trifluomeprazine, perphenazine and tetrahydrozoline into the ration at higher levels resulted in lowered feed intake and reduced rate of gain. Pigs receiving either trifluomeprazine or perphenazine were noticeably calmer than the control animals.

Literature Cited

Baird, D. M. and H. C. McCampbell. 1959. Some effects of estrogenic, androgenic and tranquilizer compounds on performance and carcass characteristics of growing-finishing swine. J. Animal Sci. 18:1495 (Abstract).

Beeson, W. M., T. W. Perry, F. N. Andrews and M. Stob. 1958. Effect of tranquilizers fed with and without stilbestrol and terramycin to steer calves. Purdue Univ. Agr. Exp. Stat. Mimeo AS 229.

Sherman, W. C., W. H. Hale, W. M. Reynolds and H. G. Luther. 1958. Nutritional studies of hydroxyzine and Rauwolfia in cattle and lambs. Proc. Soc. Exp. Biol. Med. 98:91.

Sherman, W. C., W. H. Hale, W. M. Reynolds and H. G. Luther. 1959. The effect of tranquilizers, diethylstilbestrol and oxytetracycline alone and in combination on performance of steers. J. Animal Sci. 18:198.

Snedecor, G. W. 1956. Statistical Methods (5th ed.). The Iowa State College Press, Ames, Iowa.

EFFECT OF LEVEL OF DIETARY FAT, PANTOTHENIC ACID AND PROTEIN ON PERFORMANCE OF GROWING-FATTENING SWINE [1]

W. G. Pond, E. Kwong and J. K. Loosli

Cornell University, Ithaca, N. Y.

THE addition of animal fats to rations for swine has resulted in inconsistent growth responses. Barrick *et al.* (1953) and Kennington *et al.* (1958) obtained improved rate of gain with beef tallow or peanut oil, but Heitman (1956) and Kropf *et al.* (1954) did not. However, beef tallow has consistently reduced the pounds of feed required per pound of gain (Kropf *et al.*, 1954; Heitman, 1956; Clawson *et al.*, 1956). The same has been true of lard (Day *et al.*, 1953). Soybean oil and coconut oil (Blumer *et al.*, 1957) produced satisfactory rate and efficiency of gain, but the iodine number of the back fat from pigs fed soybean oil reflected its greater degree of unsaturation in direct relationship to the length of feeding.

Hill *et al.* (1954), Matterson *et al.* (1955) and Sunde (1956) established a relationship between dietary protein and energy in influencing the growth of poultry. Lowrey *et al.* (1958) and Barnes *et al.* (1959) obtained a beneficial effect of added beef tallow on growth and efficiency of feed utilization of swine fed a high protein (18%) ration but a reduction in performance when added to a low protein (10%) ration. The reduced consumption of feed containing added fat apparently aggravated the protein deficiency of pigs consuming the low-protein ration.

Luecke *et al.* (1950, 1952) obtained pantothenic acid deficiency symptoms in growing pigs fed corn-soybean oil meal-type rations containing 4.21 mg. of this vitamin per lb. of feed.

The present study was undertaken to observe the effect of level of dietary protein and pantothenic acid on the response of growing-fattening swine to the addition of beef tallow to the ration.

Experimental Procedure

Trial 1. Yorkshire and Berkshire weanling pigs were used. Six outcome groups of eight pigs were formed on the basis of ancestry and weight. Each group was randomly assigned in a 2 x 2 x 2 factorial arrangement of treatments. The variables were protein level, fat level and pantothenic acid level. Table 1 contains the composition of the rations.

Pigs were housed in groups of six in concrete pens, 9′ x 9′, with outside concrete runways 9′ x 10′. Feed was supplied from self feeders and fresh water was supplied from metal troughs.

[1] Department of Animal Husbandry and Graduate School of Nutrition.

TABLE 1. COMPOSITION OF RATIONS IN TRIAL 1

Ration no.[a]	1, 5		2, 6		3, 7		4, 8	
	a[b]	b	a	b	a	b	a	b
Ingredients, lb.								
No. 2 yellow corn	88.5	93.5	77.5	82.5	65.0	70.0	53.85	58.85
Soybean oil meal (44%)	5.0	1.0	5.0	1.0	28.9	24.9	28.9	24.9
Meat scraps (55%)	4.0	3.0	5.5	4.5	4.0	3.0	5.5	4.5
Dicalcium phosphate	1.5	1.5	1.0	1.0	1.1	1.1	0.75	0.75
Salt (trace mineralized)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Stabilized beef tallow	...	...	10.0	10.0	...	...	10.0	10.0
Antibiotic supplement[c]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin supplement[d]	+	+	+	+	+	+	+	+
Calc. crude protein, %	12.05	10.13	11.89	10.02	20.40	18.63	20.20	18.50
Calc. TDN, %[e]	77.5		87.9		77.3		87.6	
Calc pantothenic acid mg./lb.[f]	2.99		2.73		4.77		4.50	

[a] Rations 5, 6, 7 and 8 were supplemented with d-calcium pantothenate to provide 5 mg. pantothenic acid per lb. of feed in addition to that supplied by ration components.

[b] (a) Fed to an average of 140 lb. body wt., (b) fed from 140 lb. to market wt.

[c] Aurofac 2A supplied by American Cyanamid Co., Pearl River, N. Y. contains 3.6 gm. of chlortetracycline per lb.

[d] Vitamin A, D, riboflavin, niacin, choline chloride and vitamin B_{12} were added to supply 400 I.U., 90 I.U., 1, 5, 51.2 and 0.05 mg./lb. of feed respectively. Zinc carbonate was added to supply 54 ppm. Zn.

[e] Based on the following TDN values: corn, 80.1; soybean meal, 78.1; meat scraps, 66.7; beef tallow, 182.4 (95% dry matter x 90% digestibility x 2.25). The values for corn, soybean meal and meat scraps were taken from *Feeds and Feeding* by F. B. Morrison, 22nd ed., appendix table I.

[f] Applies to unsupplemented rations (1, 2, 3, and 4). Based on the following composition in mg./lb.: corn, 2.7; soybean meal, 10.1; and meat scraps, 2.3. The values were taken from National Research Council Publication 295, Nutrient Requirements for Swine, 1953.

Individual pigs were weighed biweekly and feed consumption of each group was measured throughout the trial. Pigs were removed from the trial and live backfat probes were made (Hazel and Kline, 1952) when they reached approximately 200 lb. The test was terminated after 132 days and the performance of pigs that remained on test was computed on the basis of their final weight. These pigs were then grouped together and fed to market weight on ration 3b.

Two pigs from each group were randomly selected for blood collection on days 33, 77 and 109. Blood was drawn from the anterior vena cava and allowed to clot. On days 132, 147, and 160 the pigs which remained on test were bled in the same way. Total serum protein was determined by the method of Gornall *et al.* (1949); serum albumin was determined electrophoretically by the method of Durrum (1950) and serum cholesterol by the method of Abell *et al.* (1952).

Trial 2. Yorkshire pigs from four litters were allotted at an average weight of approximately 42 lb. to seven outcome groups of four pigs on the basis of ancestry and weight. Each group was randomly assigned to treatment. The rations were as follows: No. 1, high-protein, no added fat (same as ration 3, trial 1); No. 2, high-protein, added fat (same as ration 4, trial 1); No. 3, ration 2, trial 2 to 120 lb. then ration 1, trial 2; No. 4, a standard control ration composed of No. 2 yellow corn, 74.1; soybean oil meal, 13.9; meat scraps, 5.0; dehydrated alfalfa meal, 5.0;

dicalcium phosphate, 0.5; salt (trace mineralized), 0.5; and, antibiotic-vitamin supplements,[2] 1.0%. The protein content was reduced in lots 1, 2 and 3 at 150 lb. from 20 to 18% and in lot 4 it was reduced from 16 to 12% by changing the amount of corn, soybean oil meal and meat scraps.

The pigs were handled the same as in trial 1. The trial was ended after 102 days and the performance of pigs which remained on test was computed on the basis of their final weight.

Results and Discussion

Trial 1. The performance of pigs in trial 1 is summarized in tables 2 and 3. The data were treated statistically by methods described by Snedecor (1956). High protein (20–18%) rations promoted significantly greater ($P<0.01$) average daily gains than low protein (12–10%) rations; high energy (10% added beef tallow) rations promoted significantly greater ($P<0.01$) rate of gain than low energy (no added fat) rations in the presence of high but not low protein. It is of interest to note the significant effect ($P<0.05$) of outcome group on performance on low protein rations, reflecting the effect of ancestry and weight on protein requirement.

Pantothenic acid level had no effect on any of the criteria measured at either level of protein or energy, despite the fact that the calculated amount present in the unsupplemented low protein ration was only about two-thirds of that recommended by the National Research Council (1959).

TABLE 2. EFFECT OF LEVEL OF DIETARY FAT, PROTEIN AND PANTOTHENIC ACID ON PERFORMANCE OF GROWING-FATTENING SWINE

Trial 1 (6 pigs per group, av. initial wt. 44 lb.)

	No added pantothenic acid				Added pantothenic acid			
Lot no.	1	2	3	4	5	6	7	8
Treatment[a]	LP-LF	LP-HF	HP-LF	HP-HF	LP-LF	LP-HF	HP-LF	HP-HF
Av. daily gain, lb.	0.99	1.13	1.45	1.68	1.22	1.10	1.47	1.74
Av. daily feed, lb.	4.00	3.76	4.95	4.88	4.46	3.68	4.83	4.73
Av. daily TDN, lb.	3.10	3.31	3.83	4.23	3.46	3.23	3.73	4.10
Av. feed/lb. gain, lb.	4.04	3.34	3.43	2.90	3.65	3.35	3.30	2.73
Av. TDN/lb. gain, lb.[b]	3.13	2.94	2.65	2.51	2.83	2.94	2.55	2.36
Av. daily protein, lb.	0.46	0.43	0.98	0.96	0.51	0.42	0.95	0.93
Av. protein/lb. gain, lb.[c]	0.47	0.38	0.68	0.57	0.42	0.38	0.65	0.54
Protein/lb. gain / TDN/lb. gain	0.15	0.13	0.26	0.23	0.15	0.13	0.26	0.23
Av. backfat, in.	1.20(4)[d]	1.44(4)	1.15(6)	1.22(6)	1.31(4)	1.22(3)	1.04(6)	1.26(6)

[a] LP-low protein (12% to 140 lb., 10% from 140 lb. to market); HP-high protein (20% to 140 lb., 18% from 140 lb. to market); LF-low fat (no added fat); HF-high fat (10% added beef tallow).

[b] High protein rations (3, 4, 7 and 8) significantly less ($P<0.01$) than low protein rations (1, 2, 5 and 6).

[c] High protein rations (3, 4, 7 and 8) significantly greater ($P<0.01$) than low protein rations; non-fat rations (1, 3, 5 and 7) significantly greater ($P<0.01$) than high fat rations (2, 4, 6 and 8).

[d] Number probed is in parentheses.

[2] Acknowledgement is made to the Borden Company, New York, N. Y., for supplying the Hopro R, and to American Cyanamid Company, Pearl River, N. Y., for supplying the Aurofac 2A. Hopro R was added (0.5% of ration) to supply 1.875 mg. procaine pencillin and 5.625 mg. bacitracin per lb. of feed plus vitamins A, D, B_{12}, niacin, riboflavin and pantothenic acid and 110 ppm. zinc carbonate. Aurofac 2A was added (0.5% of ration) to supply 18 mg. of chlortetracycline per lb. of feed.

TABLE 3. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN IN TRIAL 1

Source	d.f.	Mean square
Outcome group	5	0.2818*
Ration	7	0.4177**
Protein (P)	1	2.2751**
Energy (E)	1	0.1813
Pantothenic acid (PA)	1	0.0514
P x E	1	0.2423
P x PA	1	0.0123
E x PA	1	0.0581
P x E x PA	1	0.1035
Error	35	0.0890
Total	47	

Effect of protein level on response to added fat

	Low protein		High protein	
Source	d.f.	Mean square	d.f.	Mean square
Outcome group	5	0.4340*	5	0.0209
Energy	1	0.0022	1	0.4213**
Error	17	0.1245	17	0.0212
Total	23		23	

* Significant difference among treatments ($P<0.05$).
** Highly significant difference among treatments ($P<0.01$).

Maner (1958) observed no increase in the pantothenic acid requirement of weanling pigs by the addition of fat to the ration. Barnhart *et al.* (1957) observed that levels of pantothenic acid as low as 2.0 mg. per lb. of feed promoted normal growth. This is contrary to the results of Luecke *et al.* (1950) who reported pantothenic acid deficiency in swine fed unsupplemented corn-soybean oil meal-type rations.

The average daily consumption of rations containing added fat was in all cases less than that of corresponding non-fat lots. However, the average daily calculated TDN consumption was higher for pigs in high-energy than in normal-energy lots (except for pigs in lot 6, which consumed less TDN per day than those in lot 5).

The average TDN required per pound of gain was significantly less ($P<0.01$) in the high than the low protein lots. The average TDN required per pound of gain was less in three of the four cases when fat was added to the ration, but this effect was not significant. The protein required per pound of gain was significantly greater ($P<0.01$) for the high than the low protein lots but was reduced significantly ($P<0.01$) by the addition of fat at either protein level.

The average back fat thickness of pigs fed high energy rations was greater, though not significantly, than that of pigs fed rations containing no added fat.

TABLE 4. EFFECT OF LEVEL OF DIETARY PROTEIN AND FAT ON SERUM CHOLESTEROL LEVELS OF GROWING-FATTENING SWINE IN TRIAL 1

Lot no.	Treatment[a]	Day of trial 33	77	109	132[b]	147	160
		Serum cholesterol, mg./100 ml.					
1 & 5	LP-LF	87(4)[c]	116(4)	135(2)	134(5)	127(5)	111(5)
2 & 6	LP-HF	126(4)	127(4)	133(2)	143(5)	124(5)	106(4)
3 & 7	HP-LF	76(4)	75(4)	94(4)	...	...	...
4 & 8	HP-HF	92(4)	118(4)	108(2)	...	...	...

[a] LP-low protein, LF-low fat, HP-high protein, HF-high fat. LP-LF and LP-HF significantly greater ($P<0.05$) and HP-LF and HP-HF on days 33, 77 and 109. LP-HF and HP-HF significantly greater than LP-LF and HP-LF on day 33 ($P<0.01$) and on day 77 ($P<0.05$).

[b] All 10 pigs remaining on test were fed ration 3b (high-protein) beginning on day 132.

[c] No. of observations is in parentheses. Pigs used for first three determinations were randomly selected on day 33. Pigs used for last three determinations were those remaining on test (weighed less than 200 lb.) on day 132.

The serum cholesterol of pigs fed low protein rations remained significantly higher ($P<0.05$) than that of pigs fed high-protein rations throughout the trial (see table 4). This agrees with the observation made by Barnes *et al.* (1959).

The pigs that remained on test after 132 days, and which were, therefore, those with the slowest growth rate, were protein deficient as evidenced by high serum cholesterol and low serum albumin and total serum protein levels. Serum cholesterol decreased markedly (see table 4) and serum protein and albumin increased when a high protein ration was fed for 4 weeks (see table 5).

Trial 2. The performance of pigs in trial 2 is summarized in table 6. Essentially the same response to added fat was obtained in pigs fed the high protein ration as in trial 1. The average daily gain of pigs fed the high-energy ration (lot 2) was greater ($P<0.06$) than that of pigs fed the normal-energy ration (lot 1). When beef tallow was removed from the ration at 120 lb. (lot 3) the over-all performance to market weight was midway between that obtained with normal energy throughout and with high energy throughout. The average daily weight gain of pigs fed the control ration (16–12% protein) was not significantly different from that

TABLE 5. EFFECT OF ADEQUATE DIETARY PROTEIN ON SERUM PROTEIN AND GROWTH OF PROTEIN-DEFICIENT SWINE IN TRIAL 1

Lot no.	Treatment[a]	Day of trial 1–132[b]	133–160	132	147	160	132	147	160
		Av. da gain, lb.		Serum protein, gm./100 ml.			Serum albumin, % of total		
1	LP-LF-LPA	0.72(3)[c]	1.81(3)	4.8(3)	6.3(3)	6.7(3)	17.9	18.6	43.6
2	LP-HF-LPA	0.66(2)	1.29(2)	5.0(2)	5.8(2)	6.3(1)	11.1	13.0	49.2
5	LP-LF-HPA	0.92(2)	1.44(2)	5.2(2)	7.0(2)	7.1(2)	44.2	27.1	45.1
6	LP-HF-HPA	0.86(3)	1.77(3)	4.9(3)	6.5(3)	6.7(3)	21.2	30.6	46.8
	Average	0.79(10)	1.66(10)	5.0(10)	5.9(10)	6.8(9)	24.1	23.9	45.6

[a] LP-low protein, LF-low fat, LPA-low pantothenic acid, HF-high fat, HPA-high pantothenic acid.

[b] All pigs fed ration 3 beginning on day 133.

[c] Number of observations is in parentheses.

of pigs fed the high protein-normal energy ration, but the average feed required per pound of gain was slightly greater.

The apparent increase in the efficiency of protein utilization observed in these studies may not have real significance, in that the greater rate of gain of pigs fed high protein-high energy rations than those fed high protein-normal energy rations may merely reflect greater fat deposition by the former group. The tendency for greater backfat thickness in pigs fed high energy rations supports this hypothesis. However, the observation made by Lowrey *et al.* (1958) that the apparent digestibility of protein may be increased in the presence of added fat should be studied further.

TABLE 6. EFFECT OF ADDED FAT ON PERFORMANCE OF GROWING-FATTENING SWINE

Trial 2 (7 pigs per group, av. initial wt. 42.5 lb.)

Lot no.	1	2	3	4
Treatment[a]	HP–LF	HP–HF	HP–HF[b]	Control
Av. daily gain, lb.	1.53	1.65	1.54	1.56
Av. daily feed, lb.	4.83	4.47	4.48	5.34
Av. daily TDN, lb.	3.75	3.92	3.65	4.02
Av. feed/lb. gain, lb.	3.15	2.70	2.91	3.43
Av. TDN/lb. gain, lb.	2.44	2.38	2.37	2.58
Av. daily protein, lb.	0.94	0.87	0.87	0.77
Av. protein/lb. gain, lb.	0.61	0.53	0.57	0.49
Protein/lb. gain / TDN/lb. gain	0.25	0.22	0.20	0.19

[a] HP-high protein (20% to 150 lb., 18% from 150 lb. to market); LF-low fat (no added fat); HF-high fat (10% added beef tallow); control—16% protein to 150 lb., 12% from 150 lb. to market, no added fat.

[b] Beef tallow removed at 120 lb. (same as ration 1).

Concurrent increases in body protein and fat deposition may have mutually contributed to the increase in rate of body weight gain observed in these studies. Nitrogen balance and/or body composition studies must be made to resolve these apparent effects of fat on protein utilization.

Summary

Seventy-six Yorkshire and Berkshire weanling pigs were used in two trials to study the effect of level of dietary energy, protein and pantothenic acid on performance.

High protein (20–18%) rations produced significantly greater ($P<0.01$) rate of body weight gain than low-protein (12–10%) rations. The addition of 10% stabilized beef tallow increased rate of gain significantly ($P<0.05$) with the high protein ration but not with the low protein ration.

Level of pantothenic acid had no effect on any of the criteria measured, even though the unsupplemented low protein rations were calculated to contain less than NRC recommendations.

Average daily feed consumption was decreased in the presence of added fat but average daily calculated TDN consumption was increased. Average TDN and protein required per pound of gain were reduced by added fat at both protein levels. Average backfat thickness was slightly greater, though not significantly, in pigs fed high energy rations, indicating that the increased rate of body weight gain of pigs fed those rations may have been a reflection of increased fat deposition.

Serum cholesterol level was higher in pigs fed the low protein rations than in those fed the high protein rations. Serum cholesterol was reduced and serum albumin and total serum protein were increased by feeding a high protein ration to pigs previously consuming the low protein ration.

Literature Cited

Abell, L. L., B. B. Levy, B. B. Brodie and F. E. Kendall. 1952. A simplified method for the estimation of total cholesterol in serum and demonstration of its specific gravity. J. Biol. Chem. 195:357.

Barnes, R. H., E. Kwong, W. G. Pond, R. S. Lowrey and J. K. Loosli. 1959. Dietary fat and protein and serum cholesterol. II. Young swine. J. Nutr. 69:269.

Barnhart, C. E., D. V. Catron, G. C. Ashton and L. Y. Quinn. 1957. Effects of dietary pantothenic acid levels on the weanling pig. J. Animal Sci. 16:396.

Barrick, E. R., T. N. Blumer, W. L. Brown, F. H. Smith, S. B. Tove, H. L. Lucas and H. A. Stewart. 1953. The effects of feeding several kinds of fat on feed-lot performance and carcass characteristics of swine. J. Animal Sci. 12:899 (Abstract).

Blumer, T. N., E. R. Barrick, W. L. Brown, F. H. Smith and W. W. G. Smart, Jr. 1957. Influence of changing the kind of fat in the diet at various weight intervals on carcass fat characteristics of swine. J. Animal Sci. 16:68.

Clawson, A. J., T. N. Blumer and E. R. Barrick. 1956. The influence of high-fat rations adjusted to constant protein and energy ratio on feeding performance and carcass characteristics of swine. Proc. Assoc. So. Agr. Workers 56:77.

Day, B. N., G. C. Anderson, V. K. Johnson and W. L. Lewis. 1953. The effect of a high-fat ration on swine gains and carcass quality. J. Animal Sci. 12:944.

Durrum, E. L. 1950. A microelectrophoretic and microionophoretic technique. J. Am. Chem. Soc. 72:2942.

Gornall, A. G., C. J. Bardawill and M. M. David. 1949. Determination of serum protein by means of the buiret reaction. J. Biol. Chem. 177:751.

Hazel, L. N. and A. E. Kline. 1952. Mechanical measurement of fatness and carcass value of live hogs. J. Animal Sci. 11:313.

Heitman, H. 1956. Use of stabilized tallow in swine rations. J. Animal Sci. 15:1046.

Hill, F. W. and L. M. Dansky. 1954. Studies on the protein requirement of chicks and its relation to dietary energy level. Poul. Sci. 29:763.

Kennington, M. H., T. W. Perry and W. M. Beeson. 1958. Effect of adding animal fat to swine rations. J. Animal Sci. 17:1166 (Abstract).

Kropf, D. H., A. M. Pearson and H. D. Wallace. 1954. Observations on the use of waste beef fat in swine rations. J. Animal Sci. 13:630.

Lowrey, R. S., W. G. Pond and J. H. Maner. 1958. The effect of the calorie: protein ratio on digestibility, feed efficiency and weight gain in growing swine. J. Animal Sci. 17:1165 (Abstract).

Luecke, R. W., W. N. McMillen and F. Thorpe, Jr. 1950. Further studies of pantothenic acid deficiency in weanling pigs. J. Animal Sci. 9:78.

Luecke, R. W., J. A. Hoefer and F. Thorpe, Jr. 1952. The relationship of protein to pantothenic acid and vitamin B_{12} in the growing pig. J. Animal Sci. 11:238.

Maner, J. H. 1958. Effect of energy density of the ration on the pantothenic acid requirement of the growing pig. M.S. Thesis, University of Georgia.

Matterson, L. D., L. M. Potter, L. D. Stinson and E. P. Singsen. 1955. Studies on the effect of varying protein and energy levels in poultry rations on growth and feed efficiency. Poul. Sci. 34:1210.

Snedecor, G. W. 1956. Statistical Methods (5th ed.). The Iowa State College Press, Ames, Iowa.

Subcommittee on Swine Nutrition. National Research Council. 1959. Publication 648. Nutrient Requirements of Swine.

Sunde, M. L. 1956. A relationship between protein level and energy level in chick rations. Poul. Sci. 35:350.

A PROPOSED METHOD FOR REMOVING SOURCES OF ERROR IN BEEF CATTLE FEEDING EXPERIMENTS[1, 2]

J. H. MEYER, G. P. LOFGREEN AND W. N. GARRETT

University of California, Davis

WEIGHT gain has long been one of the most commonly used criteria of steer response; but is weight gain consistent enough in composition to be a sufficiently reliable measurement? Is too much confidence being placed in a measurement that may vary in caloric and protein content from steer to steer, from treatment to treatment, or from experiment to experiment? The purpose of this paper is to explore this problem and to suggest methods for reducing errors in beef cattle experiments involving liveweight gain.

From the time of Lawes and Gilbert (1859) various researchers have been concerned about body composition of ruminants. Fortunately, body composition has, for all practical purposes, resolved itself simply into the major components—protein, water, ash and fat—and with reliable predictive relationships between them. Reid *et al.* (1955) have recently reviewed these relationships and have suggested a method for calculating the energy values of feeds utilizing a knowledge of body water content. Body water is, however, difficult to determine. Even though antipyrine and other dilution techniques have been suggested and used successfully by some, not all workers have been satisfied with these methods (Garrett *et al.*, 1959). Other techniques utilizing such compounds as tritium and deuterium (Keys and Brozek, 1953) have not been proved with ruminants and probably will not prove routinely adaptable to most beef cattle trials. Remaining, however, is the use of carcass specific gravity to predict carcass and body composition (Kraybill *et al.*, 1951–52). Carcass specific gravity is adaptable to routine use and does not require expensive equipment.

Difference in the content of the digestive tract, primarily in the reticulorumen, can also influence the magnitude and composition of liveweight. The variability of this influence can be reduced by a 10- to 15-hour fast from feed and water before liveweights are taken (Whiteman *et al.*, 1954; Koch *et al.*, 1958) but, nevertheless, experimental treatments or environmental conditions could cause variation in rumen fill.

Experimental

The University of California over the last few years has conducted a series of experiments with beef steers from which data are available on

[1] The authors express their appreciation to Dr. W. C. Rollins and Dr. F. D. Carroll for the use of some of their data and for their advice and help in this study.

[2] Department of Animal Husbandry.

TABLE 1. INFLUENCE OF RETICULO-RUMEN FILL

Item of interest	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Final wt., lb.	1000	738	1025	913	880	1055
C. V.[a]	9.6	7.4	7.7	7.3	7.4	8.0
Rumen content, lb.	59	44	71	50	52	58
C. V.	32	23	72	42	56	29
Empty body,[b] lb.	940	693	954	869	828	997
C. V.	8.7	7.5	6.6	5.8	6.4	7.4
Carcass, lb.	584	418	595	519	503	628
C. V.	9.2	9.1	7.6	6.4	6.6	6.7

Analysis of Covariance[c]

Source of variation	Degrees of freedom	Mean square: Weight gain	Final weight	Empty body	Carcass
Treatments	5	71410	71597	63923	31865
Error	41	2418	2418	1831	695
"F"	..	29.5	29.5	34.9	45.9

[a] Coefficient of variation.
[b] Final liveweight minus reticulo-rumen contents.
[c] The independent variable was initial weight.

initial and final liveweight, carcass weight, carcass grade and carcass specific gravity. These data were used to develop the method proposed in this paper. Weighing conditions included a 12-hour stand without feed and water. Specific gravity was determined by weighing the carcass in air and under water as outlined by Kraybill *et al.* (1951–52).

An equation, however, was not available for calculating the carcass ether extract. Consequently the data from the papers by Kraybill *et al.* (1951–52) and Kraybill *et al.* (1951) were used to calculate the following equation:

$$Y=487.5-439.8X$$

Y=carcass fat in percent
X=specific gravity of the carcass

The correlation coefficient between the specific gravity of the dressed carcass and the percent carcass fat was —.98; the standard error of the estimate was 1.7. From this the major chemical components were estimated by the equations and procedures developed by Reid *et al.* (1955). The caloric value of the carcass was calculated using 9367 kcal./kg. in fat (Blaxter and Rook, 1953) and 5686 kcal./kg. in protein (Garrett *et al.*, 1959). Statistical procedures were applied as suggested by Snedecor (1956).

Results and Discussion

Selected first for study was the effect of digestive tract contents on data from investigations with beef steers. Data from the experiments of Lofgreen and Otagaki (1960) were suitable because the contents of the reticulo-

rumen were weighed. Even though these steers had not been fed or watered for 12 hours, large differences were found between treatments (table 1). Individual contents varied from 28 to 108 lb. The difference in extremes between lot means, 27 lb., expressed as daily gain would represent 0.3 and 0.15 lb. per day for 90 and 180 days respectively. Obviously this is not real gain and could cause erroneous results and interpretations.

The influence of recticulo-rumen contents on the variation within a treatment was as serious as the variation between treatments. In this case the final weight corrected to an empty body basis reduced the coefficients of variation (table 1). Furthermore, a reduced error mean square made the analysis of covariance more efficient when the empty body was used. It is difficult in most experiments, however, to weigh the reticulo-rumen contents immediately after the final experimental weights are taken. Carcass weight, however, is not difficult to obtain. This corrects not only for weight of digestive tract contents but other offal as well.

A possible error remains—that of the influence of reticulo-rumen fill on initial weight—but this is difficult to eliminate. Nonetheless, it can be minimized by: (1) allowing a 12- to 24-hour fast from feed and a 12-hour fast from water before initial weights are taken; (2) previously feeding

TABLE 2. FAT, PROTEIN AND CALORIC CONTENT OF CARCASSES

Specific gravity	Fat[a]	Protein[b]	Energy[c]	Specific gravity	Fat	Protein	Energy
	%	%	kcal./lb.		%	%	kcal./lb.
1.094	6.3	20.3	793	1.056	23.1	16.7	1410
1.092	7.2	20.1	825	1.054	24.0	16.5	1443
1.090	8.1	19.9	858	1.052	24.8	16.3	1475
1.088	9.0	19.7	891	1.050	25.7	16.1	1508
1.086	9.9	19.5	923	1.048	26.6	15.9	1540
1.084	10.7	19.3	955	1.046	27.5	15.7	1573
1.082	11.6	19.1	988	1.044	28.3	15.5	1605
1.080	12.5	19.0	1020	1.042	29.2	15.3	1637
1.078	13.4	18.8	1053	1.040	30.1	15.1	1670
1.076	14.3	18.6	1085	1.038	31.0	14.9	1702
1.074	15.1	18.4	1117	1.036	31.9	14.7	1735
1.072	16.0	18.2	1150	1.034	32.7	14.5	1767
1.070	16.9	18.0	1182	1.032	33.6	14.3	1800
1.068	17.8	17.8	1215	1.030	34.5	14.2	1832
1.066	18.7	17.6	1247	1.028	35.4	14.0	1864
1.064	19.5	17.4	1279	1.026	36.3	13.8	1897
1.062	20.4	17.2	1313	1.024	37.1	13.6	1929
1.060	21.3	17.0	1346	1.022	38.0	13.4	1960
1.058	22.2	16.9	1378	1.020	38.9	13.2	1993

[a] Y=487.5—439.8X where Y=percent carcass fat and X=carcass specific gravity.
[b] Calculated from 21.64% protein in the fat-free dry matter.
[c] Caloric value of fat, 9,367 kcal./kg. (Blaxter and Rook, 1953). Caloric value of protein, 5,686 kcal./kg. (Garrett *et al.*, 1959). This figure was used because it was determined on a dry fat and ash-free basis, whereas the one given by Blaxter and Rook, 1953, 5,322 kcal./kg., is on a dry ash-free basis, corresponding to a tissue containing 16% nitrogen. The figure given by Blaxter and Rook is also much lower than values obtained by other workers for fat-free organic matter.

all animals the same ration to eliminate ration effects on fill; and (3) recognizing that a large weight gain during the experiment will tend to minimize the effect of initial weight variations.

Carcass weight had generally lower coefficients of variation than final weight but more important was the greatly reduced mean square for error (table 1). Use of carcass weight instead of weight gain or final weight adjusted to equal initial weight materially increased the efficiency of the analysis of covariance.

Dressing percent (carcass weight x 100 divided by final body weight) measured to a certain extent the influence of reticulo-rumen fill but also was influenced by carcass fat content. A study of the relationship of reticulo-

TABLE 3. RELATION OF GRADE AND CARCASS FAT[a]

Trial no.	Choice		Good		Standard		Utility	
	No.	Fat	No.	Fat	No.	Fat	No.	Fat
		%		%		%		%
1	..	.....	15	18.4±2.3	25	14.0±2.0	2	9.0±1.8
2	..	.....	..	.....	33	12.3±2.2	1	6.8
3	29	24.3±2.3	43	19 5±2.3	..	.....	..	.....
4	53	23.4±3.2	9	18.0±2.5	..	.....	..	.....
5	5	22.5±2.2	29	18.8±3.1	7	13.5±2.3	..	.....
6	..	.....	14	16.7±2.9	33	14.4±2.5	2	9.6±1.6
Weighted mean	87	23.6	110	18.7	100	13.5	5	8.8

[a] Given are the mean and standard deviation.

rumen fill and carcass fat to dressing percent was made on the data of Lofgreen and Otagaki (1960). This relationship is described by: $Y = 57.3 - 0.09X_1 + 0.27X_2$ where Y is dressing percent, X_1 is reticulo-rumen contents in lb. and X_2 is percent carcass fat. The multiple correlation was $R = 0.87$ while the standard error of the estimate was 1.06. The standard partial regression of dressing percent on rumen fill was —.89 (independent of carcass fat) while the standard partial regression of dressing percent on carcass fat was 0.74 (independent of fill). The magnitude of these effects on dressing percent was similar.

It appears therefore that irrespective of composition, carcass weight (adjusted in a covariance analysis to equal initial weight) as a criterion for making experimental decisions has distinct advantages over final weight adjusted to equal initial weights (or weight gain) and dressing percent. First, variation due to reticulo-rumen fill was reduced and the statistical analysis was more precise and efficient when carcass weight was used. Second, two statistics, weight and dressing percent, must be considered whereas one criterion, carcass weight, would be more useful. The statistical analysis and the resulting judgment would be simplified and more exact.

Third, the carcass is the main economic end product and would thus receive the most attention.

Even though carcass weight adjusted in an analysis of covariance to equal initial weights seems to be superior to final liveweight or weight gain because variation caused by offal is largely eliminated, the carcass still could vary in protein and caloric content. Table 2 shows the variation in caloric and protein content of carcasses; the change in caloric value is particularly great. No doubt much of the meaning of an experiment would be lost if the caloric content varied from treatment to treatment and were not taken into consideration in some manner.

Often carcass grade is used as an indication of fat content and hence caloric and protein value. Carcass grade, however, depends on visual judgments and also shows variation in fat content (table 3). The standard deviation of 2.55 (weighted average) represents about 91 kilocalories per lb. If it would be desirable to estimate the fat content from grade and feel reasonably assured that the estimate (95% confidence limits) was within one percentage unit of the mean, then 26 carcasses would be required. This is larger than the number most experiment stations use in each lot of their experiments. Moreover, finish is only one of the factors that enters into carcass grade. Consequently it does not seem possible to place a great deal of reliability on carcass grade when interpreting experiments with small numbers.

Most investigators usually have to examine three statistics—weight gain, dressing percent and carcass grade. Carcass weight combines the first two statistics. One step further would be to have one over-all statistic to study for interpretation of experimental results. This could be accomplished by obtaining specific gravity on all carcasses at the end of the trial. Then from a knowledge of specific gravity or fat content, a corrected carcass weight could be calculated which would be equivalent in caloric and protein content. Data from table 2 were used to devise an equation which uses specific gravity to adjust carcass weights to a level of 1,297 kilocalories per lb., which is equivalent to a carcass containing 17.3% protein and 20% fat where:

Corrected carcass=C (14.30—12.51 S.G.), and C=weight of carcass, and S.G.=specific gravity of the carcass.

Fat content could also be used where:

Correct carcass=C (0.432+0.0284 F), and C=weight of carcass, and F=carcass fat in percent.

Any corrected carcass basis could be selected but one with 20% fat and 17.3% protein was selected because it was between most good and choice carcasses (table 3). This then would allow comparisons in a growth and fattening trial with a term which has equal value for all treatments—namely, a carcass corrected to equal caloric value. A system such as this has precedent in the suggestion by Gaines (1928) for converting milk to a fat corrected basis. Additionally one over-all statistic, the corrected car-

cass adjusted to equal initial weight in an analysis of covariance, would be used to compare treatments rather than three—weight gain, dressing percent and carcass grades.

Table 4 reports some data which illustrate the value of comparison terms which have equal value for all treatments. Weight gain or final weight in this study did not show significant differences between lots 1 and 3 but carcass weight revealed real differences between these lots, showing that in this case carcass weight was more indicative than liveweight. Furthermore, correcting the carcasses to equal caloric value, because of differing fat content in the carcasses, produced even greater differences between

TABLE 4. A COMPARISON OF VARIOUS CRITERIA IN EVALUATING AN EXPERIMENT [a]

Lot number	1	2	3	4
Initial weight, lb.	593	594	597	596
Final weight, lb.	931	860[c]	922	970[b]
% of Lot 1	100	92	99	104
Dressing percent	57.2	56.4	60.5	58.4
Carcass weight, lb.	533	486[c]	558[b]	578[c]
% of Lot 1	100	91	105	108
Carcass fat, %	20.1	17.9	23.0	27.1
Corrected carcass weight, lb.	537	458[c]	610[c]	694[c]
% of Lot 1	100	85	113	129
Carcass grade:				
No. choice	9	3	7	9
No. good	..	6	2	..

[a] Data from the paper of Weir *et al.* (1959).
[b] A statistically significant difference at the 5% level from Lot 1.
[c] A statistically significant difference at the 1% level from Lot 1.

lots 1 and 3. This effect was true for all comparisons, and it demonstrates that a corrected carcass comparison has the very distinct advantage of presenting a comparison with more nearly the same composition rather than using weight gain, a term with uncertain composition. Further evidence is also presented as to the unreliability of carcass grade as an estimate for degree of finish in experiments with small numbers of steers per lot. Lot 1 with only 20.1% fat in the carcass had 9 choice steers while lot 4 with 27.1% fat in their carcasses had also 9 choice steers. Furthermore, lot 3 had fewer choice steers but had more fat in their carcasses than in lot 1.

In the use of the corrected carcass (after adjustment to equal initial experimental weights) emphasis is placed on initial weight influence on the outcome. That this relationship occurs and was linear in these trials is not surprising since the weight of the animal at the beginning is part of the weight at the end of a trial. Initial weight in most of the experiments

TABLE 5. STANDARD PARTIAL REGRESSIONS

Trial no.	No. of steers	% carcass fat on initial weight independent of gain	% carcass fat on gain independent of initial weight	Gain on initial weight independent of carcass fat
1	36	0.51[a]	0.20	−.33
2	39	0.18	0.32	0.29
3	39	0.40[b]	0.12	0.28
4	31	0.39[b]	0.15	0.28
5	42	0.32	−.41[b]	0.44[a]
6	34	0.22	−.12	0.25
7	43	0.48[a]	0.10	−.25
8	32	0.37[b]	0.18	0.34[b]
9	84	0.08	0.32[a]	0.01
10	48	0.31[b]	0.43[a]	−.03
11	31	−.60[a]	−.37[a]	−.51[a]

[a] Statistically significant at the 1% level.
[b] Statistically significant at the 5% level.

studied also had an influence on the carcass fat content (table 5). The regression was positive in all cases except one. Here very large steers were used and little weight gain occurred. In some cases a significant standard partial regression was found between carcass fat and gain independent of initial weight. In others, gain was significantly related to initial weight. From these data it was concluded that a design which makes use of an analysis of covariance involving the corrected carcass and adjusted to equal initial weight is the superior one.

The question arose as to whether an analysis of covariance with randomization of the animals to the treatments was more efficient than co-

TABLE 6. CORRECTED CARCASS WEIGHTS FROM UNIFORMITY TRIALS COMPARED IN VARIOUS EXPERIMENTAL DESIGNS

Trial	No. per treatment[a]	Error mean square: Analysis of variance	Error mean square: Analysis of covariance[e]	
		Randomized blocks[b]	Balanced[c]	Randomized[d]
1	9	2781	2172	1625
2	10	2828	2716	2455
3	10	4639	5476	4729
4	8	4497	3823	3400
Mean		3654	3562	3393

[a] Four treatments per trial.
[b] Steers assigned to each block by initial weight.
[c] Steers assigned to each treatment so that the mean initial weight was equal.
[d] Steers assigned to each treatment at random.
[e] Independent variable was initial weight.

variance with balancing of the treatments to equal beginning weights or an analysis of variance with blocking on initial weight. A question of this kind has been discussed by Lucas (1951). He presented arguments that with small numbers covariance with balancing might be more reasonable. Four experiments were available where steers had been fed the same ration for the entire trial and carcass weights and specific gravity were available. The steers in each experiment had been sired by four bulls in two cow herds. These steers were considered satisfactory for uniformity data because in most nutrition experiments it is not possible to have information about the sire and dam of each steer. These steers were then assigned to four treatments balanced to equal treatment initial weight. This was then repeated and the steers randomized to four treatments (table 6). An inspection of the variances showed little differences between the designs that were used. Accordingly, it appears that in designs which use 8 to 10 steers per treatment, randomization would be preferred since the likelihood of bias in the estimate of error is minimized. Covariance as used with corrected carcass weight as the dependent variable and initial weight as the independent variable assumes linearity of regression and homogeneity of group variances and regressions. Both of these assumptions were met with the data used in this paper.

As an aside, comment might be made about the relatively constant fat content of the various carcass grades reported in table 3 even though we concluded that grade was not consistent enough to be completely reliable in trials with small numbers of animals per treatment. Actually remarkable agreement occurred within a grade between trials. These grades were assigned by federal graders over a 3-year period in two different areas of California. It may be that large commercial feeding trials, if allotment is at random with 50 or more steers per treatment, might be able to use federal grade as a reliable indication of finish.

Summary

Experimental evidence is presented for the development of a method for conducting experiments with beef cattle which removes much of the variation caused by composition of the body and weight of the gastro-intestinal tract contents. The carcass as corrected to equal caloric content adjusted in an analysis of covariance to equal initial weight was shown to be a more reliable measure of animal performance than weight gain or weight gain in combination with dressing percent and carcass grade.

From a review of the evidence presented, the following seems to be the most desirable method for obtaining the maximum amount of reliable information from beef cattle feeding trials:

1. Randomize the steers to the treatments.

2. Take the initial weight after at least a 12-hour fast from feed and water and preferably a 24-hour fast from feed. (This is the most important

liveweight taken.) It is important to have previously fed the animals the same ration to eliminate ration effects on rumen fill.

3. Use liveweights taken during and at the end of the trial only as indicative of the experimental progress.

4. Obtain individual warm carcass weights at the end of the trial.

5. Determine the specific gravity on a half of each carcass. From this calculate carcass composition.

6. Adjust the carcass weights to a corrected carcass basis equivalent in caloric content. Corrected carcass=C (14.30—12.51 S.G.) where C=warm weight of carcass and S.G.=carcass specific gravity. Calories could be used as well as corrected carcass weight.

7. Analyze the data with an analysis of covariance to adjust the corrected carcass weights to equal initial weights.

Literature Cited

Blaxter, K. L. and J. A. F. Rook. 1953. The heat of combustion of the tissues of cattle in relation to their chemical composition. British J. Nutr. 7:83.

Gaines, W. L. 1928. The energy basis of measuring milk yield in dairy cows. Ill. Agr. Exp. Stat. Bul. 308.

Garrett, W. N., J. H. Meyer and G. P. Lofgreen. 1959. An evaluation of the antipyrine dilution technique for the determination of total body water in ruminants. J. Animal Sci. 18:116.

Garrett, W. N., J. H. Meyer and G. P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J. Animal Sci. 18:528.

Keys, A. and J. Brozek. 1953. Body fat in adult man. Physiol. Rev. 33:245.

Koch, R. N., E. W. Schleicher and V. H. Arthaud. 1958. The accuracy of weights and gains of beef cattle. J. Animal Sci. 17:604.

Kraybill, H. F., O. G. Hankins and H. L. Bitter. 1951. Body composition of cattle. I. Estimation of body fat from measurement *in vivo* of body water by the use of antipyrine. J. Applied Physiol. 3:681.

Kraybill, H. F., H. L. Bitter and O. G. Hankins. 1951–52. Body composition of cattle. II. Determination of fat and water content from measurement of body specific gravity. J. Applied Physiol. 4:575.

Lawes, J. B. and J. H. Gilbert. 1859. Experimental inquiry into the composition of some of the animals fed and slaughtered as human food. Phil. Trans., Pt. II:494.

Lofgreen, G. P. and K. K. Otagaki. 1960. The net energy of blackstrap molasses for fattening steers as determined by a comparative slaughter technique. J. Animal Sci. 19:392.

Lucas, H. L. 1951. Institute of Statistics Mimeograph Series No. 18. Univ. of North Carolina.

Reid, J. T., G. H. Wellington and H. O. Dunn. 1955. Some relationships among the major chemical components of the bovine body and their applications to nutritional investigations. J. Dairy Sci. 38:1344.

Snedecor, G. W. 1956. Statistical Methods. Iowa State College Press, Ames. Iowa.

Weir, W. C., J. H. Meyer, W. N. Garrett, G. P. Lofgreen and N. R. Ittner. 1959. Pelleted rations compared to similar rations fed chopped or ground for steers and lambs. J. Animal Sci. 18:805.

Whiteman, J. B., P. F. Loggins, D. Chambers, L. S. Pope and D. F. Stevens. 1954. Some sources of error in weighing steers off grass. J. Animal Sci. 13:832.

USE OF PROGESTERONE AND ESTROGEN IN THE CONTROL OF REPRODUCTIVE ACTIVITIES IN BEEF CATTLE[1]

L. C. ULBERG[2] AND C. E. LINDLEY

Mississippi State University, State College

THE effect of exogenous progesterone, and other hormones, in the control of ovarian activity has been reported for most species of farm livestock. Generally this activity can be controlled within certain limits. There are, however, factors yet unknown, which contribute to the variation within these limits. There is also a tendency for a decrease in fertility in some species where animals are mated at the estrus subsequent to treatment. For any system of controlled ovarian activity to be most practical the time of ovulation should be highly predictable and not decrease the pregnancy rate.

This report is concerned with the results of a series of 10 trials with beef cattle in an attempt to ascertain which factors cause variation in response as determined by interval from treatment to estrus or ovulation and the pregnancy rate subsequent to treatment.

Materials and General Methods

This series of trials began in the Spring of 1953 and continued through the Fall of 1956, a total of 458 estrous cycles being studied. Most animals were used only once during the experiment. Generally, virgin heifers were used during the Fall period and were slaughtered to verify palpation findings. The females of the commercial breeding herd were used during the Spring period with the results of treatment determined by rectal palpation.

Hormones were dissolved in sesame or corn oil in concentrations to permit the administration of the proper hormone dosage in 0.5 or 1.0 cc. of oil per injection. Unless specifically stated otherwise animals were handled in the following manner. The progesterone was administered subcutaneously in the shoulder region daily for 14 days, beginning on a given date. Estrogen when used in the sequence, was in the form of estradiol benzoate, and was administered once 96 hours after the last injection of progesterone, intramuscularly in the round muscle. Animals were checked for estrus twice daily at approximately 12-hour intervals. A female was considered in estrus when she would stand to be mounted by another cow

[1] Published with the approval of the Director of the Mississippi Agricultural Experiment Station as Journal Paper No. 833 from the Department of Animal Husbandry. The following persons assisted in the collection of portions of the data used in this study: C. W. Alliston, R. F. Boulware, S. P. Crockett, R. E. Deese, R. A. Edger, J. P. Fontenot, J. T. Morrow, T. B. Patterson, B. G. Ruffin. The generous supply of progesterone and estradiol benzoate was made available by International Hormones Inc., Brooklyn, N. Y. and Chas. Pfizer, Terre Haute, Ind.

[2] Present Address: Animal Industry Department, North Carolina State College, Raleigh, N. C.

or by a vasectomized bull. Ovarian structures and changes were determined by rectal palpation. Matings were from natural service or artificial insemination using beef or dairy bulls with semen of acceptable quality as determined by motility and concentration of sperm. Those ova observed to have cleaved yolk material and equal sized blastomeres by microscopic observation were considered fertilized.

Grade females of the three major beef breeds were used. Some of the virgin heifers were cross-bred between the three breeds. The animals were arbitrarily grouped into four reproductive classes based upon their reproductive condition at the beginning of the trial: Class I, virgin heifers (usually 18–24 months of age); Class II, nonparous heifers (those which failed to settle during first breeding season); Class III, dry parous cows and, Class IV, lactating cows.

The weaning weights for calves from cows in Class IV were corrected for differences due to year, sex and age. The birth weights and gestation length for calves born subsequent to treatment were compared for possible treatment effect.

Results

Treatment Effect upon Onset of Estrus. Variation in the length of interval from the end of the progesterone injection period to the time when estrus was first noticed was due to a number of factors. Dosage level of progesterone was one such factor. Table 1 shows the dispersion of onset of estrus for the different hormone treatments. A total of 101 animals received 25 mg. of progesterone without estrogen per day. Of this group 83 were observed in estrus within 10 days after the last hormone injection. The average interval from the last progesterone injection to onset of estrus was 4.8 days with a range of 3.0 to 9.0 days. This can be compared with the response obtained in 94 animals from a group of 117 treated with 50 mg. of progesterone without estrogen per day. The average interval for them was 5.7 days, with no decrease in the range.

In a further attempt to study controlled onset of estrus, a group of virgin heifers were subjected to four different hormone treatments subsequent to a standard injection period of 50 mg. progesterone per day for 14 days (Trial IV). A gradual decrease in progesterone level brought about by the injections of 30, 20 and 10 mg. of this hormone on the first, second and third days post standard injection period, respectively, delayed onset of estrus by about a day. Ten mg. progesterone on the third day post standard injection period had very little effect. When 10 mg. estradiol benzoate was injected on the third day post progesterone treatment, the onset of estrus generally occurred within 24 hours.

The effect of administering estrogen to progesterone-treated animals was studied in Trial V. The dosage levels were the same as for Trial IV, except the estrogen level was lowered to 8.0 mg. All estrogen-treated animals were in heat for the first time 4 days after the last progesterone injection (24

TABLE 1. VARIATION IN ONSET OF ESTRUS AFTER LAST PROGESTERONE INJECTION (SUMMARY FOR TREATMENT)

Dosage		Number of animals		Days after last progesterone injection															
Prog.	Est.	Treated	In estrus	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½
mg./day	mg.			Number of animals															
12.5	0	5	3	..	..	1	..	..	..	..	..	..	1	1	..	..	..	..	..
25	0	101	83	..	..	5	10	14	15	14	7	10	4	3	..	..	..	1	..
50[a]	0	117	94	..	..	1	1	9	9	19	13	13	8	14	3	1	1	1	1
Sub-total		223	180	..	..	7	11	23	24	33	20	23	13	18	3	1	1	2	1
12.5	1.25	4	4	..	1	3	..	..	..	..	..	..	..	..	..	..	..	..	..
25	0.5	10	9	..	2	4	..	3	..	..	..	..	..	..	..	..	..	..	..
25	1.0	10	10	1	1	2	1	4	1	..	..	..	..	..	..	..	..	..	..
25	2.0	42	41	1	1	7	7	24	..	1	..	..	..	..	..	..	..	..	..
50	5.0	4	4	..	..	3	1	..	..	..	..	..	..	..	..	..	..	..	..
50	8.0	35	34	..	..	..	..	32	1	1	..	..	..	..	..	..	..	..	..
50	10.0	9	9	..	..	..	1	6	1	1	..	..	..	..	..	..	..	..	..
Sub-total		114	111	2	5	19	10	69	3	3	..	..	..	..	..	..	..	..	..

[a]Includes 18 animals in Trial V which received supplemental progesterone injections.

hours after the estrogen injection). Eleven of the 12 animals which received progesterone only had an average interval to onset of estrus of 5.2 days with a range of 4.0–6.0 days. By pooling observations from Trials IV and V a standard deviation for the onset of estrus for the various post-progesterone treatments are as follows: no further treatment, 0.72 days; daily decrease of progesterone of 30, 20 and 10 mg., 0.49 days; 10 mg. of progesterone 3 days later, 0.85; and, estrogen 3 days later, 0.17 days.

In an attempt to verify time of ovulation the stage of embryonic development was determined in heifers mated to high fertility bulls. Five non-hormone treated heifers slaughtered 69–100 hours after first noticed in heat produced five embryos with 4–32 cells. Five heifers were injected with progesterone only, then slaughtered 69–93 hours after first notice of estrus subsequent to treatment. One ovum not cleaved, one with a ruptured zona pellucida and three ova with 4 or 16 cells were recovered from this group. The five heifers which received estrogen after the progesterone injections and slaughtered 72–96 hours after first notice of estrus produced five ova all with 16 cells.

The effect upon ovulation time of estrogen when administered 54.5 hours after the last progesterone injection was specifically tested on 16 heifers in Trial VII. These heifers were checked at two-hour intervals for estrus by use of a vasectomized Jersey bull, and for ovulation by rectal palpation. Ovulation was then verified by slaughter.

The four non-hormone treated heifers were in estrus for 10–18 hours (average 14 hours) and ovulated 28–34 hours after the onset of estrus (average 32.5 hours). Estrus in four heifers following 50 mg. progesterone daily was 14–18 hours in length (average 16 hours). Ovulation occurred 30–38 hours after onset of estrus (average 35 hours). The four animals which received 50 mg. progesterone followed by 5 mg. estrogen had estrus lengths of 14 to 28 hours (average 20.5 hours). It was more difficult to determine the limits of estrus in these four heifers. At slaughter one heifer had a large follicle (18 mm. in diameter) with no evidence of an ovulation and another had a 15 mm. follicle with an ovulation. The remaining two heifers ovulated 20 and 32 hours after onset of estrus. In the four heifers with injections of 12.5 mg. progesterone per day followed by 1.25 mg. estrogen, the length of estrus was 16–26 hours (average 23 hours). Ovulation occurred 30–36 hours (average 32.5 hours) after onset of estrus.

Table 1 summarizes the response to all dosages as measured by variation in onset of estrus. Estrus was delayed more than 96 hours beyond the last progesterone injection (24 hours beyond the time of estrogen injections) in only 6 of 109 animals when estrogen was given as compared with 139 of 182 animals when no estrogen was given. Estrus was detected in significantly more of the animals when estrogen was administered (Chi-square 16.36, $P<0.01$). Animals in the same reproductive class and on the same dosage level responded differently during different trials suggesting that a particular animal within a group will respond more like her contempo-

TABLE 2. CORRELATION OF BODY WEIGHT WITH LENGTH OF INTERVAL FROM END OF TREATMENT TO ONSET OF ESTRUS

Dosage progesterone	Reprod. class	No. observed in estrus	Average body wt.	Average interval	Correlation
mg./day				days	
25	I	47	788	4.6	−.029
	IV	22	1035	5.1	−.143
50	I	50	667	5.8	−.143
	IV	17	1008	5.3	0.438*

* $P<0.05$.

raries than like similar animals treated at a different time. In an attempt to study the effect of other factors on post treatment estrus, comparisons were made on all animals in Reproductive Class I which received either 25 or 50 mg. of progesterone only. The number of days from beginning of estrus to beginning of treatment was not significantly correlated with interval from treatment to onset of estrus. These correlation values were 0.143 for 21 animals on the 25-mg. dosage level and .000 for 35 animals on the 50 mg. level. Body weight at time of treatment was significantly correlated with the length of this interval in cows that were injected with the higher dosage while suckling calves. No such correlation was observed in animals not lactating or lactating animals on the lower dosage. Also dosage level influenced time of onset of estrus in heifers but not in cows suckling calves (table 2). From this it would appear that dosage-reproductive class interaction might be caused by lactation effect on body weight.

Treatment Effect on Pregnancy Rate. In preliminary observations of heifers, there were no indications of a marked reduction of fertilization rate due to the injections of 12.5 to 50 mg. of progesterone daily. The effect of the addition of an estrogen to the treatment sequence on fertilization rate was checked in Trial V (table 3). Also, pregnancies were determined in 297 animals by slaughter or rectal palpation 31–62 days post mating. The results are shown in table 4.

TABLE 3. TREATMENT EFFECT ON FERTILIZATION (TRIAL V)

Dosage progesterone/estrogen	Number of ova			
	Recovered	Abnormal	Fertil[1]zed	Range in no. of cells
Dosage mg.				
None/None	5	0	5	4–32
50/0	5	1	3	4–16
50/8	5	0	5	16

TABLE 4. TREATMENT EFFECT ON PREGNANCY RATE

Progesterone/estrogen	First service Number of cows			Second service Number of cows		
	Insem.	Embryos	%	Insem.	Embryos	%
None/None	106	50	50.9	36	9	25.0
25/0	64	20	31.2	41	23	56.0
50/0	40	7	17.2	39	20	51.0
50/8	26	4	15.4	19	10	53.0
25/0.5	9	1	11.1	..	..	....
25/1.0	10	2	20.0	..	..	....
25/2	42	16	38.1	17	7	41.0
Total	297	100	33.7	152	69	45.4

The hormone combination which gave the highest rate of pregnancy immediately following treatment and yet allowed synchronization of insemination was 25 mg. progesterone daily (for 14 days) followed 72 hours later by 2 mg. estradiol benzoate. This treatment was specifically tested in Trial IX on 96 cows during May 1956. The results are shown in table 5. The number of pregnancies was about the same in each group; however, the number of days required for inseminations varied between groups. The 32 cows which received estrogen after progesterone were inseminated over a 2-day period; 26 of the 32 which received progesterone only were inseminated over a 6-day period; and 31 cows in the group of 32 controls required 41 days for first service. The numbers of embryos produced from all inseminations during a 41-day breeding period were 18, 23 and 20 for the groups which received no hormones, received progesterone only, and received

TABLE 5. PREGNANCY RATE WHEN PROGESTERONE TREATMENT IS FOLLOWED BY ESTROGEN (TRIAL IX)

Dosage prog./est.	Reproductive class	Number treated	First service[a]		Number of embryos from a 41-day breeding period
			Number inseminated	Number of embryos	
mg.					
0/0	III	10	10	3	..
	IV	22	21	11	..
Total		32	31	14	18
25/0	III	10	8	2	..
	IV	22	18	10	..
Total		32	26	12	23
25/2	III	9	9	3	..
	IV	23	23	9	..
Total		32	32	12	20

[a] By first 10 days post hormone treatment in treated animals, or for 41 days in the non-hormone treated group.

progesterone followed by estrogen, respectively. It was further noted in this trial, that the injection of estrogen into cows of reproductive Class IV tended to decrease the interval between pre-treatment parturition and insemination. However the decrease was observed primarily in those animals in which pregnancy failed to occur (table 6). This may have indicated that hormone-treated cows came in heat sooner after parturition but with a decrease in fertility. By the time of the second estrous period the postpartum interval had increased and fertility appeared to be normal. The second estrous period includes the first estrus beyond 10 days post treatment in the treated animals plus the second estrus in the non-treated

TABLE 6. INTERVAL FROM PARTURITION TO INSEMINATION (TRIAL IX, REPRODUCTIVE CLASS IV)

Dosage prog./est.	Pregnant		Not pregnant	
	No. of cows insem.	Average interval from parturition	No. of cows insem.	Average interval from parturition
mg.		days		days
		First estrous period		
0/0	11	70.2	10	66.5
25/0	10	66.3	8	66.6
25/2	9	67.6	14	53.8
		Second estrous period		
0/0	0	....	5	82.2
25/0	5	86.4	5	78.2
25/2	5	71.0	5	75.2

[a] First estrus beyond 10 days post treatment plus second estrus in control animals.

animals. The percent of these cows pregnant within each treatment group by the end of the second estrous period was 50 (11/22), 68 (15/22) and 61 (14/23) for the non-treated, progesterone alone and progesterone followed by estrogen groups, respectively.

The presence of a palpable follicle (10 mm. in diameter) at the last progesterone injection enhanced the chance for a successful insemination at the estrus subsequent to treatment (table 7). Ovarian conditions were determined on a total of 137 individuals in which a corpus luteum was detected in 74, a follicle detected in 21 and no significant structures were detected in 42. The percentages of these cows pregnant, as determined by rectal palpation, were 29.7, 52.4 and 16.7, respectively. Statistical analysis, according to the method of Chi-squares, indicated that the group with detectable follicles at end of treatment had a higher percentage of successful inseminations than the group with no detectable ovarian structures ($P<0.01$). The difference between the group with detectable follicles and the group with corpora lutea approached significance at the 5% level of probability (Chi-square, 3.70).

The effect of body weights of animals during the time of treatment was studied in Trials VI, VIII and IX. There was no indication that animals (within trial, reproductive class and treatment) with body weights on one side of the mean weight could better support embryonic development than those on the other.

Treatment Effect upon the Producing Abilities of the Cow. The weaning weights of the calves suckling cows during treatment were corrected for differences between year, sex and age.The average corrected weaning weight for 62 calves suckling non-treated cows was 372 lb. Calves on cows which received 25 mg. and 50 mg. progesterone daily weighed 381 and 371 lb. respectively. Sixteen calves on cows which received 50 mg.

TABLE 7. EFFECT OF OVARIAN STRUCTURES AT END OF PROGESTERONE INJECTION UPON EMBRYO SURVIVAL [a]

	Ovarian structure present					
	CL		Follicle		None	
Progesterone	No. insem.	No. preg.	No. insem.	No. preg.	No. insem.	No. preg.
mg.						
50	28	4	5	2	17	3
25	46	18	16	9	25	4
Total	74	22	21	11	42	7

[a] Structures determined by palpation (*per rectum*).

progesterone plus one injection of 8 mg. of estradiol benzoate and 15 calves on cows receiving 25 mg. progesterone plus one injection of 2 mg. estradiol benzoate weighed 368 and 372 lb., respectively. From these observations it is concluded that estrous synchronization has no marked effect upon milk production of the cow during treatment.

There were no detectable differences in the average gestation length or birth weight of calves produced by matings made within 10 days post treatment. The average gestation length and birth weight for the non-treated cows were 288 days and 66 lb., respectively. These averages for the various hormone-treated groups ranged from 284 to 287 days for gestation lengths, and 64 to 69 lb. for birth weights. There was no indication that the sex ratio was affected by the hormone injections. Seventeen female calves were born from 36 non-treated cows whereas 13 female calves were born from 22 hormone-injected cows.

Discussion

Problems of controlled estrus are reviewed by Donker *et al.* (1958) and Ulberg (1955). It is generally concluded that progesterone will inhibit estrus in cows during the treatment period. On the cessation of treatment

estrus will occur in most animals over a relatively short range of time, but the rate of diagnosed pregnancies from inseminations made at this time is decreased. Observations made in this study were in accord with the previously reported data in that none of the 337 treated animals was observed in estrus during the period of injections. Of the 223 animals injected with 12.5–50.0 mg. progesterone alone, 180 were in estrus during the first 10 days after the cessation of injections (80.7%). This compares with 80% reported by Dziuk *et al.* (1958) for 60 dairy cows in estrus by 20 days post treatment when 25–60 mg. progesterone were administered daily.

The precentage of diagnosed pregnancies for the higher dosage of progesterone in this study was 17. Again this is in accord with data on dairy animals (Trimberger and Hansel, 1955) and beef heifers (Nellor and Cole, 1956). The administration of 0.5 to 10 mg. estradiol benzoate, given 2.5–3.0 days after the last progesterone injection, increased the percentage of cows with observed estrus during the first 10 days post treatment (97% of 114 cows so treated). This treatment sequence hastened the onset of estrus when compared with the response in those animals in which progesterone alone normally delayed estrus beyond the fourth day after the last progesterone injection. Much of the variation due to dosage level of progesterone, reproductive class, body weight and trial was also removed by this treatment. However, the animals treated with the higher dosage of estrogen and checked for estrus at 12-hr. intervals tended to respond with a normal length estrous period. This would be followed with a period of about 24 hours in which no signs of estrus were observed. The animal would ovulate during this period (determined by rectal palpation). Then another estrous period, normal in length, would occur. This second estrus did not occur when lower dosages of estrogen were administered.

It is logical to expect an estrogen to bring an animal into estrus. So it next becomes necessary to determine its effect upon ovulation in relation to the time of onset of estrus when used in this sequence. Ovulation can be induced in progesterone-injected rats by the administration of an estrogen (Everett, 1948). More recently it has been shown that the priming of estrous and anestrous rabbits with estradiol benzoate will facilitate the release of the ovulating hormone from the pituitary by vaginal stimulation. In some instances ovulation occurred, after such treatment, without the vaginal stimulation (Sawyer and Markee, 1959). The data from this study can be interpreted in accord with these premises. There is no indication that the relationship between onset of estrus and ovulation is changed in animals injected with the estrogen. In estrogen-treated animals the stage of embryonic development 3 days post mating verified that ovulation occurred at the normal time in relation to the beginning of estrus as determined by rectal palpation. Further evidence can be seen from the pregnancy rate in animals which had received estrogen. Since inseminations were timed on the basis of onset of estrus, some of the estrogen-treated

animals would have been inseminated too early had estrogen not also hastened ovulation in progesterone-treated animals, which in turn should have reduced the pregnancy rate. There is no indication that this occurred (table 4).

The synergism of progesterone with estrogen has been demonstrated to cause ovulation in the rabbit (Sawyer and Everett, 1959) and estrus in ovariectomized dairy cows (Melampy *et al.*, 1957). They showed that the timing of hormone administration as well as the dosage level were of importance in the response to treatment. Estrus resulted in the spayed dairy cows after an injection of 0.4 mg. of the estrogen. This amount corresponds to the lower dosages of estrogen used in the present report. It has been suggested that proper levels of progesterone block the release of luteinizing hormone (LH) from the pituitary in dairy heifers (Ulberg *et al.*, 1951). It can be further postulated that an estrogen acting synergistically and in the proper sequence with progesterone in some way hastens ovulation in beef cattle, possibly through the release of LH.

The results of the present study can be interpreted to mean that in beef cattle, as in laboratory animals, time of ovulation can be influenced by estradiol benzoate when administered in the proper sequence. Also, estrogen can be used to remove much of the variation in onset of estrus in progesterone-treated cows due to dosage, trial, reproductive class, and possibly body weight and condition without a further reduction in pregnancy rate.

Summary

Ten trials involving a total of 458 estrous cycles were conducted over a 4-year period to determine the ability of progesterone and estradiol benzoate to control the reproductive processes in beef cattle.

Estrus and ovulation could be inhibited by daily injections of as little as 12.5 mg. progesterone. Estrus occurred 2.5 to 9.5 days post treatment in 86% (291/337) of the animals treated. Administration of 14 daily injections of progesterone had a depressing effect upon the rate of pregnancy in animals inseminated during estrus subsequent to treatment, with the higher dosages being more detrimental.

An injection of 0.5–10.0 mg. of estradiol benzoate 3 days after the last injection of progesterone initiated estrus and caused ovulation without a further reduction in pregnancy rate. The estrogen also removed much of the variation in the onset of estrus, subsequent to progesterone administration, due to differences between groups of animals. There were no indications that any treatment affected productivity of the cow as measured by the weaning weight of calf suckling cow during the administration of the hormones, the gestation length, birth weight, or the sex ratio of calves born from inseminations during estrus subsequent to treatment. It is suggested that estrogen used in this sequence facilitates the release of the luteinizing hormone to cause ovulation in beef cattle.

Literature Cited

Donker, J. D., J. R. Nichols, E. F. Graham and W. E. Peterson. 1958. Controlled estrus in cattle. Reproduction and Infertility, III Symposium. Ed. by F. X. Gassner. Pergamon Press, N. Y., p. 171.

Dzuik, P. F., J. D. Donker, J. R. Nichols and W. E. Peterson. 1958. Problems associated with transfer of ova between cattle. Minn. Agr. Exp. Stat. Tech. Bul. 222.

Everett, J. W. 1948. Progesterone and estrogen in the experimental control of ovulation time and other features of the estrous cycle in the rabbit. Endocr. 43:389.

Kawakami, M. and Charles H. Saywer. 1959. Neuroendocrine correlates of changes in brain activity thresholds by sex steroids and pituitary hormones. Endocr. 65:652.

Melampy, R. M., M. A. Emmerson, J. M. Rakes, L. J. Hanka and P. G. Eness. 1957. The effect of progesterone on the estrous response of estrogen-conditioned ovariectomized cows. J. Animal Sci. 16:967.

Nellor, J. E. and H. H. Cole. 1956. Hormonal control of estrus and ovulation in the beef heifer. J. Animal Sci. 15:650.

Sawyer, Charles H. and John W. Everett. 1959. Stimulatory and inhibitory effects of progesterone on the release of pituitary ovulating hormone in the rabbit. Endocr. 65:644.

Sawyer, Charles H. and J. E. Markee. 1959. Estrogen facilitation of release of pituitary ovulating hormone in the rabbit in response to vaginal stimulation. Endocr. 65:614.

Trimberger, G. W. and William Hansel. 1955. Conception rate and ovarian function following estrus control by progesterone injections in cattle. J. Animal Sci. 14:224.

Ulberg, L. C. 1955. Synchronization of estrus cycles. Mich. State Univ. Cent. Sym. Report Reproduction and Infertility. p. 184.

Ulberg, L. C., R. E. Christian and L. E. Casida. 1951. Ovarian response in heifers to progesterone injections. J. Animal Sci. 10:752.

SOME VARIATION IN ESTROGENIC ACTIVITY IN FRESH AND DRIED WHITE CLOVER CLONES AND THE LADINO VARIETY

E. M. BICKOFF,[1] A. L. LIVINGSTON,[1] A. N. BOOTH,[1] C. R. THOMPSON,[2] E. A. HOLLOWELL[3] AND E. G. BEINHART[3, 4]

INTEREST in forage estrogens has been aroused in recent years for three reasons; (1) their responsibility for infertility in sheep grazing such pastures, (2) discovery that large quantities of estrogens administered to lactating cows can cause changes in milk composition and production, and (3) the known effect of estrogens on increased meat production in cattle and sheep.

Because of widespread use of Ladino white clover in pastures and because preliminary assays indicated wide variation in estrogen content, it seemed desirable to study some of the factors that would influence estrogenic activity. A cooperative experiment was established between the Crops Research Division and the Western Utilization Research and Development Division of the Agricultural Research Service and the South Carolina Agricultural Experiment Station. Clover plantings were made at Clemson, South Carolina, and at Albany, California; the bioassays for estrogenic activity were carried out at Albany, California. Factors investigated included individual clones, the variety Ladino, seasonal variations, stage of maturity, and effect of artificial drying on the estrogenic potency.

Materials and Methods

Clemson, South Carolina. Seven white clover samples were harvested for estrogen assay in 1957. These included five different clones free of bean yellow virus and a sixth clone for which both virus-free and virus infected samples were taken. The plants were grown in greenhouse benches, and all samples were taken during a single week in May, 1957, at a time when all were in full bloom.

The greatest estrogenic activity among the 1957 samples was found in the virus-infected material, suggesting that the virus may affect estrogen content in clover. To study this possibility, virus-free and virus-infected plants of each of the three clones were transplanted into field plots during the first week of March, 1958. The plants were placed on 12-inch centers

[1] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Albany, Calif.

The authors are indebted to Mrs. Ann Gramps for assistance in the preparation of samples for assay and to Mr. A. P. Hendrickson for carrying out the mouse-uterine-weight assays.

[2] Present address: University of California, Riverside, Calif.
[3] Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.
[4] South Carolina Agricultural Experiment Station, Clemson, South Carolina.

in plots 50 square feet in area. The plots were malathion sprayed frequently to reduce aphid transmission of virus.

Harvests were made in May, June, and July, 1958, representing different stages of growth. Harvesting was accomplished by clipping all leaves and flowers at a height of approximately two inches above the ground. The freshly harvested samples were dried with forced draft at 130° C. until brittle, then transferred to a convection oven and held 48 hours at 70° C. The dried samples were shipped to Albany, California, where they were assayed.

Albany, California. Only 1 planting of Ladino clover was grown at Albany. A plot 40 ft. x. 40 ft. was seeded in May 1957. Five samples harvested at 2-week intervals were obtained during the winter season of 1957–58. Four consecutive cuttings were taken during the 1958 spring and summer seasons from the 1957 seeding, and five sequential samples were collected from each cutting at intervals of about 2 weeks.

For each harvest, the aerial parts were taken from a 50- to 60-square foot area of the plot. The clover harvested for assay was, as far as could be judged, representative of the entire plot. Harvesting was accomplished as described for the Clemson samples except that the leaves and flowers were clipped at a height of approximately 1 inch from the ground.

Most samples were bioassayed after drying in a forced draft oven. However, since the drying operation may cause loss of estrogenic activity (Bickoff *et al.*, 1960), a newly developed assay procedure (Bickoff *et al.*, 1959) was used for some of the later samples. For assays of the fresh plant tissue, three representative 400-gm. portions were taken from the whole samples and the remainder was air dried in preparation for assay.

Bioassay Procedures. The mouse uterine weight method was employed for the bioassay (Bickoff, 1959). Immature mice of the Dalswiss strain, 18–21 days of age, having body weights ranging from 8–10 gm. were used The mice were randomly divided into groups of five per cage. One group was fed only the control diet, a second was fed a diet fortified with diethylstilbestrol to serve as a positive control, and the remaining groups served for assay of unknowns. In most cases, three or more replications of each sample were run at several levels.

The precision of this bioassay technique for solutions of coumestrol, stilbestrol, and a typical sample of ladino clover has been presented in an earlier paper (Bickoff *et al.*, 1959). Since coumestrol is the predominant estrogen in ladino clover, estrogenic activity has been expressed in terms of P.P.M. of apparent coumestrol, (Bickoff *et al.*, 1960). The standard dose-response curve was established by feeding known amounts of coumestrol in the diet, 15–25 mice being used to obtain the mean uterine weight response for each level fed.

Results

Clemson, South Carolina. In the 1957 harvest, virus-infected Louisiana 6 was the only one of the six clonal lines that contained considerable estro-

TABLE 1. VARIETAL DISTRIBUTION OF ESTROGENIC ACTIVITY IN WHITE CLOVER

(Plants harvested in 1957 at Clemson, S. C.)

Clover line	Date of harvest	Flower density	Apparent coumestrol
		per sq. ft.	p.p.m.
269	May 6	10	0
2682	May 6	15	0
4304	May 7	12	0
4306	May 8	10	7
Louisiana 21	May 9	9	3
Louisiana 6 (virus-free)	May 8	6	13
Louisiana 6 (with virus)	May 9	2	105

genic activity. The virus-free sample of Louisiana 6 was almost devoid of activity (table 1). The high level of activity in the former sample suggested a possible correlation between estrogenic activity and virus-infection. However, this idea was not completely borne out in the 1958 studies (table 2). The virus-infected plants of clone No. 4304 did contain considerably more estrogenic activity at each of the three harvests. However, contrary to the 1957 observations, the virus-free samples of Louisiana 6 now contained more activity than did the comparable virus-infected samples. In the case of the third clone studied, Louisiana 21, no clear-cut differences between virus-free and virus-infected samples were evident (table 2).

Furthermore, there was no apparent correlation of estrogenic activity with stage of plant development or date of the harvest. Each clone exhibited a pattern different from the other two. Thus, the virus-free samples of Louisiana 6 contained approximately the same amount of activity at

TABLE 2. VARIETAL AND SEASONAL DISTRIBUTION OF ESTROGEN IN WHITE CLOVER

(Plants harvested in 1958 at Clemson, S. C.)

Clonal material	Date of harvest	Stage of development	Apparent coumestrol	
			virus-free	with virus
			p.p.m.	p.p.m.
Louisiana 6	5/8/58	Full bloom	58	32
	6/18/58	Full bloom[a]	50	35
	7/26/58	Vegetative	48	44
Louisiana 21	5/8/58	Full bloom	0	19
	6/18/58	Full bloom[a]	34	33
	7/26/58	Vegetative	22	14
No. 4304	5/8/58	Full bloom (virus-free)	39	92
	6/18/58	Full bloom[a]	12	168
	7/26/58	Full bloom	122	170

[a] Vegetative growth of the plants is tougher, less succulent and sparser than the May crop.

each of the three harvests. However, the virus-free plants of the Louisiana 21 clone were initially inactive even though in full bloom. At the June 18th sampling the plants were more mature, although still in full boom, and they contained a moderate amount of activity. By the time of the third harvest in July, these plants had changed to a vegetative stage and the activity had decreased about one-third. The clover of clone No. 4304 bloom flowered during the entire period of study, but the estrogen activity varied from moderate to low potency in May and June to a very high value in the July sample.

Albany, California. During the period from October to January the plants continue to grow because of the mild climate but remain in a vegetative stage. Some estrogenic activity was always present and progressively increased with age of plant (tables 3 and 4). The entire aerial parts of the plants produced during the period October to January were harvested in January. The new aerial growth which began in January and was sampled progressively until seed was produced, contained estrogenic activity even at

TABLE 3. ESTROGENIC ACTIVITY OF LADINO CLOVER OF DIFFERENT AGES (ALBANY, CALIF.)

Stage of maturity	Growth period from previous cutting	Height of stand	Apparent coumestrol[a]
	weeks	inches	p.p.m.
Previous cutting harvested 10/7/57			
Vegetative	2	1	27
Vegetative	4	6	26
Vegetative	6	7	43
Vegetative	8	8	40
Vegetative	12	10	86
Previous cutting harvested 4/24/58			
Vegetative	4	4	120
Vegetative	6	6	163
Few buds	8	8	112
Moderate budding	10	8	103
Many buds	13	8	227
Many buds	15	8–10	91
Moderate blossoming	17	10–12	67
Many blossoms	19	10–12	46
⅓ seedheads	21	10–12	23
Mostly seedheads	25	10–12	73
Previous cutting harvested 7/7/58			
Heavy budding	2	3–4	44
Moderate flowering	4	6	83
Heavy flowering	6	6	82
Heavy flowering	8	6	32
Heavy flowering (many seedheads)	10	6–12	50
Heavy flowering (many seedheads)	12	6–12	66

[a] Dry matter basis.

TABLE 4. ESTROGENIC ACTIVITY OF LADINO CLOVER OF DIFFERENT AGES (ALBANY, CALIF.)

Stage of maturity	Growth period from previous cutting	Height of stand	Apparent coumestrol[a]	
			Fresh	Dried
	weeks	inches	p.p.m.	p.p.m.
Previous cutting harvested 7/7/58				
Budding	3	3–6	27	18
Heavy flowering	4½	4–6	18	17
Heavy flowering	6	4–6	23	25
Heavy flowering	8	6–8	45	88
Heavy flowering (many seedheads)	10	6–8	77	79
Mostly seedheads (many dried leaves)	12	6–8	153	110
Previous cutting harvested 10/7/58				
Vegetative	2½	2–4	37	25
Vegetative	4	3–6	74	42
Vegetative	6	3–6	28	29
Vegetative	14	3–6	136	124

[a] Dry matter basis.

the early vegetative stage, reaching a peak of activity during the budding stage. A progressive decline occurred during blossoming and initial onset of the seedhead stage, increasing slightly as the plants progressed further into the seedhead stage.

Activity in the spring cutting was the highest during the budding stage (table 3) and then decreased greatly. The early summer cutting which began growth in the latter part of April (table 3) remained in a flowering stage during most of the 3 months of its development. The estrogenic activity reached a maximum within the first month, during the early flowering stage, and then slowly declined. The maximum values were considerably lower than the corresponding values of the spring cutting.

The late summer cutting, which began growth in July, 1958, (table 4) showed a progressive increase in activity with the age of the plant. Although no correlation existed between flowering and high estrogen content, activity increased during the period from initiation of flowering to development of mature seeds.

Earlier work has shown that drying of forage may sometimes result in losses of activity (Bickoff *et al.*, 1959, 1960). In 4 of the 10 samples in which this factor was studied in the present investigation, from 20% to 40% of the estrogenic activity was lost during drying and in 5 of the samples none was lost. In one case the dried sample was twice as potent as the fresh, which may represent a sampling error.

Discussion

Pope and coworkers (1959) investigated three strains of white clover and suggested a correlation of high estrogenic activity with flowering.

Swierstra (1958) reported that white clover possessed a high estrogenic activity in the spring (May), showed a sharp decrease in July, but after August 1st, the active substances were present again in considerable quantities.

In regard to the plants grown at Clemson, the initial observation of a possible correlation of activity with virus infection was not borne out in the subsequent seasons' studies. While attempts were made to maintain virus-free material in the field, it is not certain that this was accomplished. Additional studies on virus as related to estrogens are planned. In addition, there was no clear relation of clonal line or stage of development with estrogenic content. The clone highest in activity in the 1958 studies had shown no activity in 1957.

Until recently, the information on the variety of white clover, known as Ladino has been limited. Recent investigators have reported that Ladino clover contains measurable amounts of estrogenic activity (Engle *et al.*, 1957; Pieterse and Andrews, 1956) but no studies have been reported on the correlation of activity with stage of growth or other factors.

At Albany, estrogenic activity was found in Ladino clover at all stages of maturity at all seasons of the year, and was more related to the age of the plant than to its stage of development. In fact, activity tended to increase with age even during the winter season when plants remained in the vegetative stage, although a considerable fluctuation in activity occurred within each crop. No obvious correlation was found between activity and flowering or reproductive status as was reported with other clovers.

Coumestrol is the only estrogen isolated to date from white clover including the variety Ladino (Bickoff, *et al.*, 1957; Lyman *et al.*, 1959). Curnow *et al.* (1947) and Robinson (1949) have shown that the genistein present in subterranean clover can interfere with reproduction in sheep. Likewise, Engle (1957) in a recent study has reported a reproductive disturbance in sheep grazing on Ladino clover. This suggests that coumestrol in forages may also interfere with the normal breeding of farm animals.

Correlating chemical composition with plant growth and development is difficult when the plants are grown in field plots or greenhouses because of the great variations in temperature, light intensity, and other environmental factors occurring from day to day and season to season. Studies now in progress at Clemson, however, are using controlled-environment chambers to measure growth responses of white clover to different temperatures and light intensities (Beinhart, 1959), and correlating these responses with variation in chemical composition (Beinhart, 1959a). It is planned to analyze samples from future growth chamber experiments for coumestrol by a paper chromatographic procedure (Livingston *et al.*, 1960).

Summary

Factors affecting the estrogenic activity of white clover clones and the Ladino variety were studied at two different stations. Factors included

variety, stage of maturity, age of cutting, season of the year and artificial drying. At the Clemson station, little or no correlation could be found between estrogenic activity and stage of maturity, age of stand, clone or virus infection.

At the Albany station estrogenic activity was found in the Ladino clover sampled periodically from several cuttings grown during a period of over a year, including the "winter" season. There was considerable fluctuation in activity within a given cutting and between cuttings. The estrogenic potency tended to increase with the age of the cutting during the winter season in which the material grew slowly and remained in the vegetative stage. In the early spring, the activity was highest during the budding stage and then decreased greatly as the plant matured.

Generally, slight but unpredictable losses of activity occurred during oven-drying of fresh Ladino clover samples.

Literature Cited

Beinhart, G. 1959. Effects of temperature and light intensity on growth and development of white clover. Plant Physiol. 34 Suppl., viii.

Beinhart, G. 1959a. Variation in free sugars of white clover grown at different temperatures and light intensities. Plant Physiol. 34 Suppl., viii.

Bickoff, E. M., A. N. Booth, R. L. Lyman, A. L. Livingston, C. R. Thompson and F. DeEds. 1957. Coumestrol, a new estrogen isolated from forage crops. Science 126:969.

Bickoff, E. M., A. N. Booth, A. L. Livingston, A. P. Hendrickson and E. L. Lyman. 1959. Determination of estrogenic activity in fresh and dried forage. J. Animal Sci. 18:1000.

Bickoff, E. M., A. N. Booth, A. L. Livingston and A. P. Hendrickson. 1960. Observations on the effect of drying on estrogenic activity of alfalfa samples of varying maturity. J. Animal Sci. 19:745.

Engle, P. H., D. S. Bell and R. R. Davis. 1957. The effect of ladino clover, birdsfoot trefoil and bluegrass pasture on the rate of conception among ewes. J. Animal Sci. 16:703.

Livingston, A. L., E. M. Bickoff, Jack Guggolz and C. R. Thompson. 1960. Quantitative determination of coumestrol in fresh and dried alfalfa. J. Agr. Food Chem. (in press).

Lyman, R. L., E. M. Bickoff, A. N. Booth and A. L. Livingston. 1959. Detection of coumestrol in leguminous plants. Arch. Biochem. and Biophys. 80:61.

Pieterse, P. J. S. and F. N. Andrews. 1956. The estrogenic activity of alfalfa and other feedsuffs. J. Animal Sci. 15:25.

Pope, G. S., M. J. McNaughton and H. E. H. Jones. 1959. Oestrogens in British pasture plants. J. Dairy Res. 26:196.

Pope, G. S. and H. G. Wright. 1954. Oestrogenic isoflavones in red clover and subterranean clover. Chem. and Ind. 33:1019.

Robinson, T. J. 1949. Oestrogenic potency of subterranean clover (T. Subterraneum L. var. Dwalganup): The preparation and assay of extracts. Australian J. Exp. Biol. Med. Sci. 27:297.

Swierstra, E. E. 1958. The estrogen-like substances in various legumes and grasses, and the effect of these compounds on the reproduction and growth of certain laboratory animals. Master's thesis, Univ. of British Columbia.

RELATIONSHIP OF FEED INTAKE AND LENGTH OF COLLECTION PERIOD TO APPARENT DIGESTIBILITY OF A SELF-FED, PELLETED LAMB RATION [1]

R. B. GRAINGER, N. GAY AND F. H. BAKER[2]

Kentucky Agricultural Experiment Station

IT is generally accepted that the apparent digestibility by sheep and cattle of a ration containing roughage and concentrate decreases as intake increases above maintenance (Anderson *et al.*, 1959). There are, however, no data on the effect of intake on apparent digestibility of a self-fed, fattening ration by sheep with the individual animals establishing the variation of intake within an experimental group. The following experiment was initiated to compare dry matter digestibility coefficients calculated for 3- and 7-day fecal collections with self-fed wether lambs, and to study the relationship between feed intake, body weight and dry matter digestibility of a pelleted fattening ration self-fed to wether lambs.

Experimental Procedure

Forty-two California cross-bred lambs, low in parasite load, were self-fed a pelleted ration for 28 days. The lambs, which averaged 54.1 lb., were bedded on sand in well-ventilated indoor pens. The ration was composed of 50% corn cobs (ground in a hammer mill through a 3/8″ and then a 3/16″ screen), 26.9% ground yellow corn, 12.5% soybean oil meal (44% protein), 7.0% Hydrol,[3] 0.42% $CaCO_3$, 0.67% trace mineralized salt and 2.5% Cr_2O_3 premix. The Cr_2O_3 premix contained 8% Cr_2O_3 in soybean meal. Vitamins A and D were added to furnish 2 x 10^6 I.U. of A and 1.6 x 10^6 I.U. of D per ton of feed. The mean Cr_2O_3 concentration of eight individual samples of the 3/8″ pelleted ration was 1.46 ± 0.055 mg. per gm.

After a 21-day preliminary period the lambs were fitted with modified Garrigus and Rusk (1939) harnesses and bags for 7-day total feces collections. Daily feces aliquots of 10% were combined into 0–3 day inclusive and 4–7 day inclusive composites. After the composites were dried (96 hours at 75°C.), equilibrated with atmospheric conditions and ground in a Wiley mill (80-mesh screen), 50% aliquots of each were combined to furnish a 0–7 day feces composite. The individual 3- and 7-day feces composites and feed samples were analyzed for Cr_2O_3 by the method of Bolin *et al.* (1952) to determine individual feed intake. After dry matter intake was determined by fecal Cr_2O_3 concentration, apparent dry matter

[1] The investigation reported in this paper is in connection with projects of the Kentucky Agricultural Experiment Station and is published by permission of the director.

[2] Present address: Oklahoma State University, Stillwater.

[3] Corn molasses from Corn Products Co., Pekin, Illinois.

digestibility was calculated by conventional methods. Averages of 3-day body weights taken at the end of the 28-day trial were used for correlation analyses. Statistical analyses were conducted according to methods described by Snedecor (1950).

Results and Discussion

The mean, range and standard deviation of dry matter digestibility (DMD), for the 3- and 7-day fecal collection periods were: 58.6 (36.2—72.4) ±7.30 and 59.6 (50.0—72.6) ±5.97, respectively. Analysis of variance comparing the 3- and 7-day collection periods for the 42 individual lambs showed that the difference approached significance ($P>0.05$). As

TABLE 1. RELATIONSHIP OF FEED INTAKE, BODY WEIGHT AND DRY MATTER DIGESTIBILITY

Independent variables	Dependent variables: Dry matter digestibility b	Dry matter digestibility b′	Daily intake b	Mean	Range
Body weight, lb.	0.06	0.021[1]	0.05***	70.0 ±10.6	90.8—49.5
Daily intake, lb.	1.17	−0.196[2]	....	2.95± 0.69	4.7— 1.3
Dry matter digestibility, %	....	.....	....	59.6 ± 5.97	72.6—50.0

*** $P<0.001$.
b=regression coefficient.
b′=standard partial regression coefficient.
[1] Daily intake held constant.
[2] Body weight held constant.

the collection was increased from 3 to 7 days the range and standard deviation decreased. Since the 3-day collection was represented in the 7-day collection the comparisons were biased. To obtain an unbiased comparison of the 3- and 7-day collection, 20 lambs were selected by the use of a table of random numbers to represent the 3-day collection. The remaining 20 lambs (2 lambs of the 42 lacked 1 day of the 7 days of collection) were assigned to the 7-day collection group. Analysis of variance comparing DMD of the ration by the two randomly selected groups showed a significant difference ($P<0.05$). The mean DMD and standard deviation for the 3- and 7-day collection groups were: 56.0±7.9 and 61.3±5.9 respectively. As previously noted the 7-day collection group had the least range and a lower standard deviation for DMD. These findings were in agreement with Swift (1925); however, the 3- and 7-day collection period only approached the length of collection periods (8 and 24 day) compared by Swift.

No data have been found in the available literature correlating DMD, average daily feed intake (DI) and body weight (BW) on a self-fed ful'-fed

lamb fattening ration. The mean DI and DMD for the 7-day collection period and the mean BW at the end of the 7-day collection period for the 42 lambs were 2.95±0.69 lb., 59.6±5.97% and 70.0±10.6 lb., respectively. The results of statistical analyses by multiple correlation and simple regression are shown in table 1.

Statistical treatment of the data by multiple correlation showed that no relationship existed between DMD and DI or BW. Likewise no relationship was shown between DMD and DI or DMD and BW by simple regression. However, the regression coefficient for DI on BW was highly significant ($P<0.001$). These data are not in agreement with other investigators as reviewed by Anderson (1959); however, in the feeding regimes used by those investigators the feed intake was restricted to multiples of maintenance.

As shown by Anderson (1959) when the intake increased above maintenance the DMD decreased. The data reported herein indicate no relationship between DMD and DI of wethers self-fed a fattening ration. The question then arises: Do the total digestible nutrients (TDN) values determined by conventional metabolism trials with sheep in metabolism crates and on reduced feed intake give reliable measures of TDN in full-fed, self-fed fattening rations for sheep? It is suggested by the results of this study that healthy lambs self-fed pelleted rations will have comparable DMD regardless of their self-established feed intakes.

Summary

Over 40 crossbred California wether lambs were used in a digestion study involving a 21-day preliminary and a 7-day fecal collection period. The lambs were fitted with feces collection bags and self-fed a 3/8" pelleted, fattening ration. A comparison of 3- and 7-day collection periods showed a significant difference in dry matter digestibility (DMD), the more reliable mean being obtained from a 7-day fecal collection. No relationship existed between daily intake (DI), body weight (BW) and DMD as shown by multiple correlation. Simple correlation of DMD and DI or BW showed no relationship. A highly significant relationship existed between BW and DI.

Literature Cited

Anderson, P. E., J. T. Reid, M. J. Anderson and J. W. Stroud. 1959. Influence of level of intake upon the apparent digestibility of forages and mixed diets by ruminants. J. Animal Sci. 18:1299.

Bolin, D. W., R. P. King and E. W. Klosterman. 1952. A simplified method for the determination of chronic oxide. Science 116:634.

Garrigus, W. P. and H. P. Rusk. 1939. Some effects of the species stage of maturity on the forage consumption of grazing steers of various weights. Ill. Agr. Exp. Stat. Bul. 454.

Snedecor, G. W. 1950. Statistical Methods (4th ed.). Iowa State Press, Ames, Iowa.

Swift, R. W. 1925. A biometric study of length of metabolism experiments with cattle. J. Animal Sci. 8:270.

HIGH LEVEL COPPER FOR GROWING-FINISHING SWINE [1]

H. D. WALLACE, J. T. MCCALL, BILLY BASS AND G. E. COMBS [2]

University of Florida, Gainesville

USING various plates and salt bricks, Braude (1948) demonstrated that young pigs fed a normal diet exhibited a craving for metallic copper. In 1955 Barber *et al.* (1955a) observed that the daily gains of growing pigs were significantly improved by feeding 250 p.p.m. of supplementary copper as copper sulfate. A second report by Barber *et al.* (1955b) indicated that the same high level of copper increased gains to about the same extent as did effective antibiotics. In a coordinated experiment involving eight feeding centers in England, Bowler *et al.* (1955) also determined that the addition of 250 p.p.m. of copper to usual swine rations increased gains significantly. Schurch (1956) added 230 p.p.m. of copper to the ration of pigs and noted an increased weight gain and an improved feed utilization. He suggested that the copper may have protected the pigs against an infection which affected the controls. More recently Barber *et al.* (1957) have reconfirmed previous work in which the copper effect was comparable to that obtained from chlortetracycline or oxytetracycline. They also observed that 0.5% and 1.0% copper sulfate rapidly reduced feed intake and gains. A study in this country reported by Scott (1958) involving levels of 50 and 250 p.p.m. of copper alone and in combination with chlortetracycline and/or brewers dried yeast showed that only the antibiotic increased gains significantly. Another report from England by Allen *et al.* (1958) has again confirmed the growth promoting effect of 250 p.p.m. of copper. Hawbaker *et al.* (1959) demonstrated that the copper radical and not the sulfate radical was producing the growth response in Iowa studies.

The work presented here was undertaken primarily to determine the efficacy of adding high levels of copper to corn-soybean meal type rations which are commonly fed to growing-finishing swine in this country. The interrelationship of copper and zinc fed in combination at high levels and the relationship of dietary protein level to copper toxicosis were also studied.

Experimental Procedure

All experiments were conducted in concrete confinement and feed was offered by self-feeder. The rations were typical, well fortified corn-soybean oil meal mixtures. Compositions of the basal rations used in the various experiments are presented in table 1. All copper supplementations were in

[1] Florida Agricultural Experiment Station Journal Series, No. 1090.

[2] Department of Animal Husbandry and Nutrition.

the form of copper sulfate. Zinc supplementations were made as zinc carbonate. The average copper content of the basal feed mixtures used in Experiments I through V was 22 p.p.m.

Experiment I. Twenty weanling pigs consisting of purebred Durocs and crossbreds (Hampshire x Spotted Poland China) were divided into four replicated lots of five pigs each on the basis of weight, sex and litter. Two lots served as controls and two lots were supplemented with 250 p.p.m. copper.

TABLE 1. PERCENTAGE COMPOSITION OF BASAL RATIONS FED IN THE VARIOUS EXPERIMENTS

Experiment number	I and II	III and IV	V	VI		
Calculated level of crude protein (%)	14	14	14	15	20	25
Ground yellow corn	78.5	78.5	78.5	79.4	65.7	52.1
Soybean oilmeal (44% solvent)	17.0	17.0	17.5	17.8	31.5	45.1
Ground limestone	1.0	1.0	1.0	1.0	1.0	1.0
Steamed bonemeal	1.0	1.0	1.0	1.0	1.0	1.0
Trace mineralized salt[a]	0.5	0.5[b]	0.5	...	...	...
Iodized salt	...	...	...	0.5	0.5	0.5
Trace mineral mixture[c]	...	...	...	0.1	0.1	0.1
Vitamin premix[d]	2.0	2.0	2.0	...	...	...
Vitamin supplement No. 2 (Pfizer)[e]	...	...	...	0.2	0.2	0.2

[a] Manganous sulfate ($MnSO_4 \cdot H_2O$), 1,842 gm.; ferrous sulfate ($FeSO_4 \cdot H_2O$), 796 gm.; cupric sulfate ($CuSO_4 \cdot 5H_2O$), 250 gm.; zinc sulfate ($ZnSO_4 \cdot H_2O$), 350 gm.; cobalt carbonate ($CoCO_3$), 20 gm.; and NaCl, 100 lb.

[b] The trace mineralized salt used in Experiments III and IV contained no copper or zinc.

[c] Manganous sulfate ($MnSO_4 \cdot H_2O$), 22.5%; ferrous sulfate ($FeSO_4 \cdot H_2O$), 35.0%; cupric sulfate ($CuSO_4 \cdot 5H_2O$), 1.89%; cobaltous sulfate ($CoSO_4 \cdot H_2O$), 0.50%; zinc sulfate ($ZnSO_4 \cdot H_2O$), 6.65%; potassium sulfate (K_2SO_4), 1.67%; and calcium carbonate carrier, 31.79%.

[d] Vitamin A (10,000 I.U./gm.), 20 gm.; vitamin D_2 (9,000 I.U./gm.), 2.20 gm.; vitamin E (44 I.U./gm.), 9.10 gm.; vitamin B_{12} supplement (1 gm.=½ mg. B_{12}), 0.50 gm.; calcium pantothenate, 0.30 gm.; choline chloride supplement (25%), 160 gm.; niacin, 1.00 gm.; thiamine, 0.10; riboflavin, 0.09; pyridoxine, 0.66; folic acid 0.05; and soybean oilmeal carrier, 714.60 gm.

[e] Contains a minimum of 2,000 mg. riboflavin, 4,000 mg. pantothenic acid, 24,000 mg. niacin and 104,000 mg. choline chloride per lb.

Experiment II. Forty weanling pigs of mixed breeding were divided into eight replicated lots of five pigs each on the basis of weight, sex and litter. Two lots were supplemented with each of the following levels of copper: 0, 100, 150 and 200 p.p.m. At the end of the sixth week of the experiment hemoglobin values were determined for all pigs. Hemoglobin determinations were continued at two-week intervals until the conclusion of the experiment.

Experiment III. Fifty weanling pigs of Duroc and Hampshire breeding were divided into ten replicated lots of five pigs each according to weight, sex and litter. Various supplementary levels of copper and zinc were offered. Two lots were fed each of the following levels of copper (p.p.m.) and zinc (p.p.m.), respectively: 0, 0; 4, 20; 200, 500; 0, 500; and 200, 0.

Hemoglobin values were determined for all pigs at two-week intervals throughout the experiment.

Experiment IV. Twenty-eight Duroc x Spotted Poland China crossbred weanling pigs were divided into seven replicated lots of four pigs each according to weight, sex and litter. One lot was given no copper or zinc supplementation. Two lots received 150 p.p.m. copper and 500 p.p.m. zinc. Two lots were given 150 p.p.m. copper and no zinc. One lot received 300 p.p.m. copper and 1000 p.p.m. zinc. The remaining lot received 300 p.p.m. copper and no zinc.

Experiment V. Thirty-two weanling pigs of mixed breeding were divided into eight replicated lots of four pigs each according to weight, sex and litter. Two lots were provided no copper or chlortetracycline supplementations. Two lots were supplemented with 100 p.p.m. copper but no chlortetracycline. Two lots received no supplementary copper but 20 gm. chlortetracycline per ton feed as Aurofac-10, and finally two lots received both copper and chlortetracycline at the previously mentioned levels.

TABLE 2. RESPONSE OF GROWING-FINISHING SWINE TO VARIOUS LEVELS OF COPPER

(Summary, Experiments I and II)

Experiment numbers	I		II			
Treatment group	1	2	1	2	3	4
Copper added, p.p.m.	0	250	0	100	150	200
Initial number of pigs	10[a]	10[b]	10	10	10[c]	10
Av. initial wt., lb.	25.7	24.9	53.2	53.0	53.0	53.1
Av. final wt., lb.	118.8	89.3	185.0	198.0	192.0	186.0
Av. daily gain, lb.	1.33**	0.92	1.53	1.70	1.61	1.54
Av. daily feed intake, lb.	4.10	3.15	5.00	5.65	5.20	4.97
Feed required per lb. gain, lb.	3.08	3.42	3.26	3.32	3.23	3.23
Days on experiment	70	70	87	87	87	87

[a] One pig died after 20 days on test. Autopsy did not reveal cause of death.
[b] One pig died after 56 days on test. Autopsy revealed evidence of copper poisoning.
[c] One pig died after 52 days on test. Autopsy revealed evidence of copper poisoning.
** Gains significantly faster than copper supplemented group ($P<.01$).

Experiment VI. Sixty weanling pigs of mixed breeding were divided into twelve replicated lots of five pigs each according to weight, sex and litter. Two lots were fed at each of the three crude protein levels (15, 20 and 25%) with no supplementary copper. Two lots were fed at each of the same protein levels and supplemented with 750 p.p.m. copper. Hemoglobin determinations were made starting at the end of the fourth week and at two-week intervals during the remainder of the experiment.

Data on average daily gain, feed requirement per pound gain and hemoglobin levels from all experiments were statistically analyzed by the analysis of variance.

Results and Discussion

Differences in the performance of replicated lots in the various experiments were small and non-significant. For this reason, data from replicated lots have been combined for presentation in the summary tables.

Experiment I. A summary of the results of this experiment is presented in table 2. The control pigs (Treatment I) gained significantly faster ($P<.01$) than pigs supplemented with 250 p.p.m. copper (Treatment 2). Control pigs consumed an average of almost one pound of feed more per head daily and required considerably less feed per pound of gain (3.08 vs. 3.42). One pig in the copper supplemented group died on the 56th day of the experiment after exhibiting symptoms of copper poisoning. A post mortem examination revealed internal hemorrhage and a pronounced icterus throughout the body fluids and tissues, particularly the liver. The Duroc pigs on the high level copper ration started to show a fading of the haircoat after about 5 weeks on the test. This became more pronounced as the experiment progressed. The experiment was terminated after ten weeks.

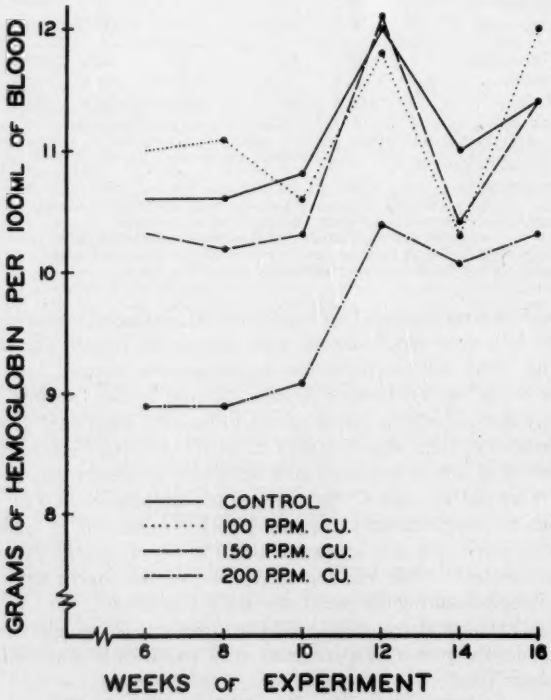

Figure 1. Hemoglobin values (Experiment II).

TABLE 3. RESPONSE OF GROWING-FINISHING SWINE TO VARIOUS LEVELS OF COPPER AND ZINC COMBINATIONS

(Summary, Experiment III)

Treatment group	1	2	3	4	5
Copper added, p.p.m.	0	4	200	0	200
Zinc added, p.p.m.	0	20	500	500	0
Initial number of pigs	10	10	10	10	10[a]
Av. initial wt., lb.	45.7	45.0	45.7	45.3	45.9
Av. final wt., lb.	178.9	174.9	176.7	172.6	174.4
Av. daily gain, lb.	1.59	1.55	1.56	1.51	1.53
Av. daily feed intake, lb.	4.79	4.85	4.91	4.96	5.01
Feed required per lb. gain, lb.	3.01	3.13	3.14	3.28	3.27
Days on experiment	84	84	84	84	84

[a] One pig died after 46 days on test. Autopsy did not reveal cause of death.

At that time all but three of the remaining animals on the copper treatment were showing visible signs of copper poisoning. These three animals were eating well and making satisfactory gains. This indication of a marked individual variation among animals in their ability to tolerate high levels of dietary copper has been substantiated in subsequent work.

Experiment II. Results of Experiment II in which lower supplementary levels of 0, 100, 150 and 200 p.p.m. copper were studied are presented in table 2. Pigs supplemented with 200 p.p.m. copper (Treatment 4) performed very similarly to the control pigs. Those supplemented with 150 p.p.m. (Treatment 3) ate slightly more feed and gained slightly faster than the control group. Pigs supplemented with 100 p.p.m. (Treatment 2) ate considerably more feed and gained faster than any of the other groups. None of the above differences proved statistically significant at the 5% level of probability. It appeared that all levels of copper stimulated feed intake during the first few weeks of the experiment. No serious evidences of copper toxicity were observed; However, one pig on the 150 p.p.m. level of supplementation died suddenly after 52 days on test. Autopsy revealed a general icterus throughout the body fluids and tissues. The progressive fading of the haircoats of Duroc pigs was again observed on the 150 and 200 p.p.m. level but not on the 100 p.p.m. There was no clear correlation between the change in haircoat color and the individual gains or performance of the pigs.

Blood hemoglobin values determined after 6 weeks of the experiment averaged 10.6, 11.0, 10.3 and 8.9 gm. per 100 ml. blood for the pigs supplemented with 0, 100, 150 and 200 p.p.m. copper, respectively. The pigs fed 200 p.p.m. supplementary copper averaged considerably lower than the others in hemoglobin during the remainder of the experiment (figure 1), indicating that this amount of copper in the form offered was excessive, even though growth was not impaired and no other symptoms of toxicity were apparent.

Experiment III. Results of Experiment III showing supplementary effects of copper and zinc are presented in table 3.

Differences in gains between the various treatments were small and nonsignificant. The basal group (Treatment I) actually gained somewhat faster and more efficiently than the other groups.

The hemoglobin values (figure 2) show that 200 p.p.m. copper markedly

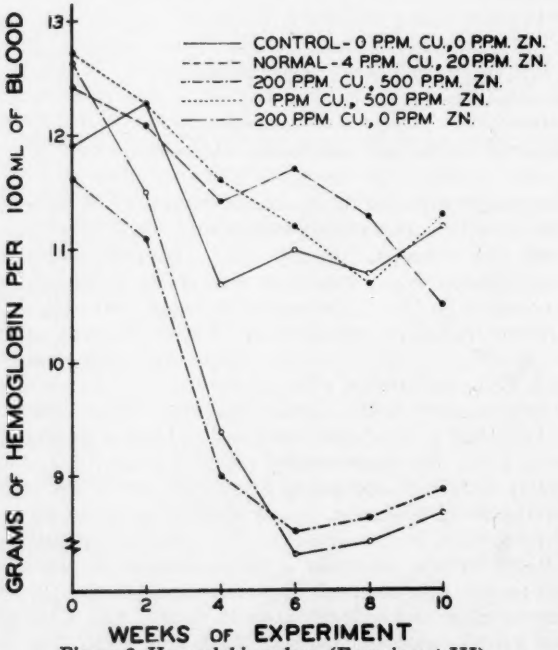

Figure 2. Hemoglobin values (Experiment III).

reduced hemoglobin level. The effect became very prononuced by the fourth week and persisted to the end of the trial. Sutton and Nelson (1937), Smith and Larson (1946) and Cox and Harris (1960) have shown that copper supplementation will alleviate anemia produced by zinc toxicity in rats. Apparently the converse is not true with swine, since the influence of 200 p.p.m. copper on hemoglobin was not altered by the presence of 500 p.p.m. zinc. No copper-zinc relationships were evident from the results of this experiment. Van Reen (1957), Davis (1958) and Allen *et al.* (1958) have reported antagonism between copper and zinc with respect to liver storage in rats.

Experiment IV. Results in which the possible interrelationships of copper and zinc were further explored are presented in table 4. The most interesting observation concerned the incidence of parakeratosis. Three of the four pigs on Treatment 1, no supplementary copper or zinc, developed severe symptoms of parakeratosis after about 5 weeks on test. No other cases were observed. All treatments, except Treatment I, involved supplementary copper or zinc or a combination of the two elements. These results, although not conclusive, would seem to corroborate the observations of Hoefer *et al.* (1960), in that copper also gives protection against parakeratosis. Since the performance of the pigs on Treatment 1 was adversely affected by the parakeratosis there can be no meaningful expression of individual treatment

TABLE 4. RESPONSE OF GROWING-FATTENING SWINE TO VARIOUS LEVELS OF COPPER AND ZINC COMBINATIONS

(Summary, Experiment IV)

Treatment group	1	2	3	4	5
Copper added p.p.m.	0	150	150	300	300
Zinc added p.p.m.	0	500	0	1000	0
Number of pigs started on test	4[a]	8	8	4	4
Av. initial wt., lb.	45.3	46.0	47.0	46.5	45.5
Av. final wt., lb.	131.8	170.3	171.3	152.3	160.8
Av. daily gain, lb.	1.24	1.76	1.78	1.51	1.65
Av. daily feed consumption, lb.	4.22	5.59	5.20	4.25	5.33
Feed required per lb. gain, lb.	3.40	3.18	2.92	2.81	3.23
Days on experiment	70	70	70	70	70

[a] Three of the four pigs in this lot were afflicted with severe parakeratosis commencing at about five weeks. This accounts for the poor performance of this group of pigs.

responses. However, in comparing Treatment 2 (150 p.p.m. Cu and 500 p.p.m. Zn) with Treatment 3 (150 p.p.m. Cu and 0 p.p.m. Zn) it was again apparent that the zinc had little influence on the performance of the pigs. The small number of pigs fed in Treatments 4 and 5 preclude any strong conclusions, but the results suggest that 1000 p.p.m. zinc fed in the presence of 300 p.p.m. copper may have slowed gains. Work by Brink *et al.* (1959) demonstrated that weanling pigs were able to tolerate 0.1% zinc in the diet while higher levels produced symptoms of zinc toxicosis. It is also evident from the present study that pigs fed 150 p.p.m. copper performed better than pigs fed 300 p.p.m.

Experiment V. Barber *et al.* (1955) reported that 250 p.p.m. of supplemental copper as copper sulfate increased gains in weanling pigs to the same extent as did effective antibiotics. Hawbaker *et al.* (1959) have reported that copper sulfate improved performance as much as oleandomycin or oxytetracycline and that the combination of copper sulfate with either of the antibiotics resulted in an additive effect on rate of gain. Experiment V compares the relative effectiveness of copper and chlortetracycline as

TABLE 5. RESPONSE OF GROWING-FINISHING SWINE TO COPPER AND CHLORTETRACYCLINE ALONE AND IN COMBINATION

(Summary, Experiment V)

Treatment group	1	2	3	4
Copper added p.p.m.	0	100	0	100
Chlortetracycline added, gm. per ton	0	0	20	20
Number of pigs started on test	8[a]	8	8[b]	8
Av. initial wt., lb.	41.1	41.1	41.6	41.1
Av. final wt., lb.	175.1	174.4	201.0	190.8
Av. daily gain, lb.	1.66	1.66	1.99**	1.86**
Av. daily feed consumption, lb.	5.98	5.08	6.48	6.05
Feed required per lb. gain, lb.	3.60	3.06	3.26	3.25
Days on experiment	80	80	80	80

[a] One pig removed after 14 days of the test because of unthriftiness.
[b] One pig removed after 42 days on test because of anal prolapse (pig had gained very well while on test).
** Significantly different from performance of pigs in Treatments 1 and 2 ($P<.01$).

growth promotants. Based on previous tests, 100 p.p.m. of copper was selected as the most likely effective level without causing toxicity. Results of the experiment are presented in table 5. The addition of 100 p.p.m. copper (Treatment 2) did not promote faster gains but did effect a considerable saving in feed when compared to the basal group (Treatment 1). Both Treatment 3 (20 gm. chlortetracycline per ton) and Treatment 4 (100 p.p.m. copper and 20 gm. chlortetracycline per ton) produced significantly faster gains ($P<.01$) than either Treatment 1 or 2. A marked improvement in feed conversion over Treatment 1 was also apparent. Results of this experiment indicate that only the chlortetracycline exerted a favorable influence on rate of gain.

Experiment VI. Results obtained in a study of the relationship of level of protein to copper toxicosis are found in table 6. A very high level of copper (750 p.p.m.) which was expected to produce severe toxic symptoms was fed with rations containing three levels of crude protein (15, 20 and

TABLE 6. THE INFLUENCE OF PROTEIN LEVEL ON COPPER TOXICITY

(Summary, Experiment VI[a])

Treatment group	1	2	3	4	5	6
Crude protein level, %	15	15	20	20	25	25
Added Cu., p.p.m.	0	750	0	750	0	750
Number of pigs per group	10	10	10	10	10	10
Av. initial wt., lb.	56.0	55.9	56.2	56.5	56.1	55.9
Av. final wt., lb.	166.0	119.6	161.5	136.2	146.0	135.7
Av. daily gain, lb.	1.43	0.83	1.37	1.04	1.17	1.04
Av. daily feed consumption, lb.	4.98	3.33	5.01	4.12	4.50	4.31
Feed required per lb. gain, lb.	3.48	4.01	3.66	3.96	3.84	4.14
Days on experiment	77	77	77	77	77	77

[a] Copper effect significant ($P<.01$). Copper-protein level interaction significant ($P<.01$).

25%). As expected, the copper proved toxic but a protective action due to protein was clearly evident. An analysis of the growth data showed a highly significant ($P<.01$) adverse effect due to the copper and a highly significant ($P<.01$) interrelationship between the copper and protein level. As the protein level increased the copper toxicosis was less pronounced. It is interesting also that the pigs performed better on 15% pro-

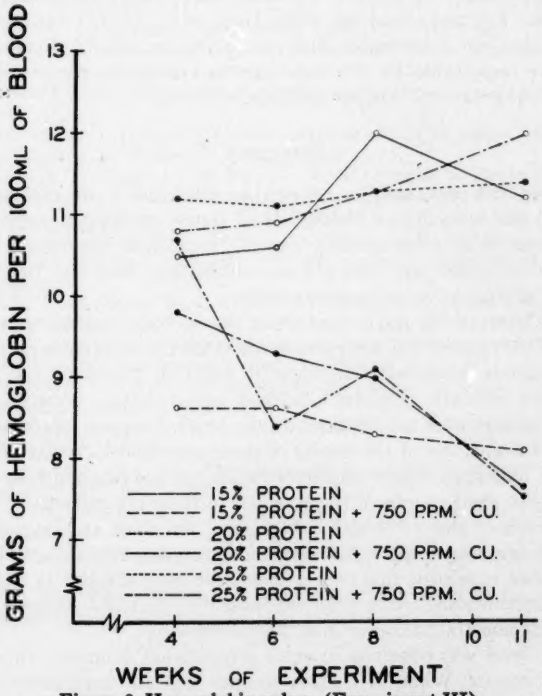

Figure 3. Hemoglobin values (Experiment VI).

tein than on 20% and better on 20% than on 25%. This is in accord with other recent observations at this station using corn-soybean meal type mixtures. At the time the trial was concluded several pigs on the copper treatments were obviously severely poisoned and probably would not have survived much longer on the rations. One pig from Treatment 2 died a few days after the trial ended.

Hemoglobin values (figure 3) show a picture very much in accord with the growth data. After 4 weeks on test, hemoglobin values revealed the same protective action from dietary protein; however, this became less apparent as the experiment progressed and when terminated all groups on

the copper rations were quite deficient in hemoglobin as compared with the untreated groups.

McCall (1958) has demonstrated that high levels of protein in the form of casein alleviated copper toxicity in rats. It is well established that low protein intakes augment the toxicity of certain other elements such as molybdenum, cobalt and selenium. The toxicity of these elements has been reduced significantly by dietary supplementation with methionine (Lewis *et al.*, 1940; Fels and Cheldelin, 1948; Dunn *et al.*, 1952; Gray and Daniel, 1954). It is quite conceivable that methionine or other individual amino acids were responsible for the reduction in toxicity in the present study through the formation of copper-amino acid chelates.

Summary

Two hundred and thirty weanling pigs were fed in six experiments to study (1) the influence of high levels of copper as copper sulfate on the performance of growing-finishing pigs; (2) possible interrelationships of high levels of copper and zinc fed in combination; and, (3) the influence of dietary protein level on copper toxicosis.

Copper levels of 250 p.p.m. and above proved toxic in these experiments. A level of 200 p.p.m. did not exert harmful effects on growth performance but hemoglobin levels were significantly reduced. Levels of 150 and 100 p.p.m. were generally non-toxic. Marked and consistent growth responses and feed savings were not obtained at any level of copper supplementation. An overall evaluation of the results of these experiments would not justify the use of high level copper supplementation for growing-finishing pigs fed corn-soybean meal rations of the type fed in these experiments.

High levels of zinc (500 and 1000 p.p.m.) fed alone and in combination with high levels of copper did not influence pig performance. Evidence was obtained indicating that copper may have been effective in the prevention of parakeratosis. Other than this possible effect, no evidence was obtained to demonstrate a copper-zinc interrelationship.

Protein level was observed to exert a significant influence on the toxic effects of copper. When 750 p.p.m. copper was fed with three levels of protein (15, 20 and 25%) the toxic effects as measured by gain, feed conversion and hemoglobin levels became less as the protein level increased.

Literature Cited

Allen, M. M., R. S. Barber, R. Braude and K. G. Mitchell. 1958. Copper and zinc supplements for fattening pigs. Proc. Nutr. Soc. (British) 17, XII.

Barber, R. S., R. Braude, K. G. Mitchell and J. Cassidy. 1955a. High copper mineral mixture for fattening pigs. Chem. and Indus. 21:601.

Barber, R. S., R. Braude and K. G. Mitchell. 1955b. Antibiotic and copper supplements for fattening pigs. British J. Nutr. 9:378.

Barber, R. S., R. Braude, K. G. Mitchell and J. A. F. Rook. 1957. Further studies on antibiotic and copper supplements for fattening pigs. British J. Nutr. 11:70.

Bowler, R. J., R. Braude, R. C. Campbell, J. N. Craddock-Turnbull, H. F. Fieldsend, E. K. Griffiths, I. A. M. Lucas, K. G. Mitchell, N. J. D. Nickalls and J. H. Taylor. 1955. High-copper mineral mixture for fattening pigs. British J. Nutr. 9:358.

Braude, R. 1948. Some observations on the behavior of pigs in an experimental piggery. The Bulletin of Animal Behaviour, No. 6, 17 N. 1. R. D. Paper No. 967.

Brink, M. F., D. E. Becker, S. W. Terrill and A. H. Jensen. 1959. Zinc toxicity in the the weanling pig. J. Animal Sci. 18:836.

Cox, D. H. and D. L. Harris. 1960. Effect of excess dietary zinc on iron and copper in the rat. J. Nutr. 70:514.

Davis, G. K. 1958. Mechanisms of trace element function. Soil Sci. 85:59.

Dunn, K. M., R. E. Ely and C. F. Huffman. 1952. Alleviation of cobalt toxicity in calves by methionine administration. J. Animal Sci. 11:326.

Fels, I. G. and V. H. Cheldelin. 1948. Methionine in selenium poisoning. J. Biol. Chem. 176:819.

Gray, L. F. and L. J. Daniel. 1954. Some interrelationships of copper, molybdenum, zinc and lead in the nutrition of the rat. J. Nutr. 40:43.

Hawbaker, J. A., V. C. Speer, J. D. Jones, V. W. Hays and D. V. Catron. 1959. Effect of copper sulfate and antibiotics on growth rate, feed conversion and fecal flora of growing pigs. J. Animal Sci. 18:1505 (Abstract).

Hoefer, J. A., E. R. Miller, D. E. Ullrey, H. D. Ritchie and R. W. Luecke. 1960. Interrelationships between calcium, zinc, iron and copper in swine feeding. J. Animal Sci. 19:249.

Lewis, H. B., J. Schultz and R. A. Gortner, Jr. 1940. Dietary protein and the toxicity of sodium selenite in the white rat. J. Pharm. and Exp. Therap. 68:292.

McCall, J. T. 1958. The interaction of copper and other dietary factors in animal metabolisms. Ph.D. Dissertation. University of Florida.

Schurch, A. 1956. The effect of high copper doses upon the weight gain of pigs. Mitt. Gebiete Lebensm. U. Hyg. 47:458.

Scott, K. W. 1958. Recent nutritional research at the University of Arkansas. Proceedings Swine Study Day. July 3.

Smith, S. E. and E. J. Larson. 1946. Zinc toxicity in rats. Antagonistic effects of copper and liver. J. Biol. Chem. 163:29.

Snedecor, G. W. 1956. Statistical Methods (5th ed.). The Iowa State College Press, Ames, Iowa.

Sutton, W. R. and V. E. Nelson. 1937. Studies on zinc. Proc. Soc. Exp. Biol. Med. 36:211.

Van Reen, R. 1953. Effects of excessive dietary zinc in the rat and the interrelationship with copper. Arch. Biochem. and Biophys. 46:337.

QUANTITATIVE ESTIMATIONS OF MYOGLOBIN AND HEMOGLOBIN IN BEEF MUSCLE EXTRACTS [1, 2]

H. P. Fleming,[3] T. N. Blumer and H. B. Craig [4]

North Carolina Agricultural Experiment Station, Raleigh

THE color of fresh beef is due largely to the concentration and chemical state of myoglobin, and perhaps to some extent hemoglobin, which remains in the tissue as residual blood. Since color is an important factor influencing consumer acceptance of fresh beef, a reliable method for determining concentrations of the component pigments is necessary in order more accurately to evaluate effects resulting from breeding and feeding studies and slaughtering methods. Several methods have been employed in quantitatively estimating these pigments in muscle extracts. Shenk *et al.* (1934), basing their calculations on oxygenated pigments, were the first to estimate the concentrations of hemoglobin and myoglobin in extracts containing both pigments. Watson's (1935) method was also based on the oxygenated pigments; but the pigments were reduced and reoxygenated before spectrophotometric readings. DeDuve (1948), Poel (1949), and Bowen and Eads (1949) determined the concentrations of the pigments in solution mixtures of the two after conversion to the carbon monoxide derivatives. Drabkin (1950) and Ginger *et al.* (1954) determined myoglobin as the cyanmet- compound after salting the hemoglobin from solution.

The purpose of the present study was to determine which of the previously used methods for estimating chromoprotein concentrations in muscle tissues would be the most accurate and adaptable as an analytical technique for beef muscle. It was considered essential that the method accurately estimate the total pigment concentration in beef muscle extracts as well as relative proportions of hemoglobin and myoglobin.

Materials and Methods

Animals. The five grade Hereford steers from which tissues were obtained for this study were fed entirely on pasture and were approximately 2 years old at the time of slaughter.

Sampling and Extraction. Samples of shank, rib eye *(Longissimus dorsi)*, and sirloin tip muscles were obtained after the beef carcasses had been

[1] Approved for publication as Paper No. 1170 in the Journal Series of North Carolina Agricultural Experiment Station.

[2] This work is cooperative with the U. S. Department of Agriculture and is a part of SM-19 Southern Regional Beef Project.

[3] From a portion of a thesis presented to the Graduate School, North Carolina State College in partial fulfillment of the requirements for the M.S. degree, 1958.

[4] Present address: Department of Animal Husbandry, Michigan State University, East Lansing, Michigan.

chilled for 48 hours. Heart samples were obtained at the time of slaughter and were thoroughly rinsed to remove surface blood.

The samples were freed of surrounding intermuscular fat and connective tissues. The meat was ground three times in a hand food-chopper and then mixed well to insure homogeneity. Duplicate 50-gram samples were weighed and then blended for 5 minutes in a Waring blender with 130 ml. of cold distilled water. After centrifuging the slurry at approximately 1000 x g for 15 minutes, the supernatant was filtered into a flask through a small wad of cotton and the extract retained. Upon extracting the resultant residue by blending for 3 minutes with 80 ml. of water, the extracts were combined, filtered through Whatman No. 3 filter paper into a 250-ml. volumetric flask and diluted to volume.

Quantitative Determinations of Pigments. Pigment determinations, by all four of the methods employed, were made on the same 250-ml. extract from each sample. Therefore, it was not possible to follow the extraction procedures originally used in the methods being tested since they differed in this respect. Otherwise, the basic principles of each procedure, as described by the original authors, were retained. All analyses were performed at room temperature with the exception of using cold water for extraction.

(1) Conversion of total pigments to cyanmet- compounds.—Twenty-five ml. of extract were treated with solutions of potassium ferricyanide and potassium cyanide to provide final concentrations of the compounds after dilution of 0.6 and 0.8 millimole per liter, respectively. A slight clouding frequently resulted which was eliminated by centrifugation and filtration. Drabkin's (1950) molar extinction coefficient of 11.3 x 10^3 for cyanmet-myoglobin (CNMMb) at a wave length of 540 mμ was used to determine total molar concentration of pigments. Molar concentrations were converted to milligrams of pigment by the formula:

$$\text{Mg. total pigments/gm. tissue} = \frac{\text{O.D.}}{11{,}300}\left[\frac{17{,}000 \times (.25 + \text{d}) \times 1000}{\text{gm. of sample}}\right]$$

where $\frac{\text{O.D.}}{11{,}300}$=molar concentration of pigment, O.D.=optical density at 540 mμ, 11,300=molar extinction coefficient of CNMMb at 540 mμ 17,000=equivalent weight of the pigments, 0.25=volume of the extract in liters, and d=volume increase due to the addition of the cyanides. The equation was multipled by 1000 to convert grams of pigments to milligrams.

(2) Conversion to carbon monoxide compounds.—A 50-ml. aliquot was removed from the extract, buffered with M/15 dibasic sodium phosphate and the concentrations of myoglobin and hemoglobin were determined by introducing carbon monoxide into the solutions in a manner similar to that described by deDuve (1948) and using Poel's (1949) method of calculation. Addition of the phosphate often resulted in a clouded solution which was clarified by centrifugation and subsequent filtration. The resulting precipitate apparently did not contain myoglobin since no red color was evident. Ten ml. of the clear solution were transferred to a Thunberg

tube which was fitted with a rubber stopper. Two inlets led through the stopper, one for the entrance of carbon monoxide and the other for the anaerobic addition of sodium hydrosulfite. A two-way stopcock made it possible to evacuate the system before entrance of carbon monoxide. Carbon monoxide was slowly bubbled through the solution for 5 minutes, the pigment reduced by releasing a small quantity of $Na_2S_2O_4$ into the solution and the bubbling resumed for 5 additional minutes.

After quickly filling an absorption cell to the top and covering so as to exclude air, optical densities at wave lengths 538 and 568 mμ were read on a Beckman DU spectrophotometer. Molar concentrations of hemoglobin and myoglobin, calculated from the extinction coefficients and equations used by Poel (1949), were multiplied by the constant factor of the previous equation to determine milligrams of pigment per gram of muscle tissue. The volume increase, d, in this case was due to addition of dibasic sodium phosphate rather than cyanides as in the previous equation.

(3) Conversion to cyanmetmyoglobin after removal of hemoglobin.—Except for the extraction procedure outlined above, myoglobin concentration was determined by the same basic procedure as outlined by Ginger *et al.* (1954) which is a modification of Drabkin's (1950) method.

(4) Pigments calculated as oxygenated compounds.—Concentrations of myoglobin and hemoglobin were determined immediately after extraction by the Shenk *et al.* (1934) method.

Solution Mixtures of Myoglobin and Hemoglobin. Purified myoglobin was prepared according to the method of Singer *et al.* (1955). A solution of myoglobin, computed to contain 0.8 gm. of myoglobin per liter, was prepared by converting the myoglobin in a diluted volume of the purified pigment to CNMMb, reading the optical density at 540 mμ, calculating the concentration by use of Beer's law and the extinction coefficient, 11.3×10^3, and subsequent dilution until the desired concentration was reached.

Fresh beef blood was defibrinated by shaking with glass beads, the serum separated by centrifugation and the blood cells washed three times with 0.85% saline solution. The washed erythrocytes were hemolyzed with distilled water and the solution filtered. A solution of hemoglobin, computed to contain 0.8 gm. of hemoglobin per liter, was obtained by diluting the solution several fold, determining the concentration by use of Beer's law and Drabkin and Austin's (1935) extinction coefficient, 11.5×10^3, and then diluting to the desired concentration.

Spectral curves for MbCO and HbCO preparations from these standard solutions were made by averaging five separate readings. Also, solutions of the two pigments were mixed, volumetrically, in varying ratios for the purpose of testing the validity of the carbon monoxide conversion method for estimating the percentages of myoglobin and hemoglobin in solution mixture of the two.

Results and Discussion

Extraction. It was found that two extractions of beef muscle removed practically all of the water soluble pigments when using 130 and 80 ml. of water, respectively. However, one 250-ml. extraction removed only 85 to 95% of the extractible pigments.

Occasionally, using water alone, the extract was cloudy and could not be cleared by centrifugation. It was later found that the use of 0.01 N acetate buffer solution, pH 4.5, as was suggested by DeDuve (1948) resulted in consistently clear extracts.

TABLE 1. MILLIGRAMS OF PIGMENT PER GRAM OF FRESH MEAT DETERMINED BY VARIOUS METHODS

		Total pigment as			Myoglobin as		
Animal	Muscle	Cyanmet-[a]	Carbonyl-[b]	Oxy-[c]	Cyanmet-[d]	Carbonyl-[b]	Oxy-[c]
23	Shank	3.40	3.30	3.03	2.15	3.18	2.09
70	"	3.12	3.20	3.07	2.34	3.15	2.30
75	"	3.38	3.40	3.22	2.30	3.33	2.27
Av.	"	3.30	3.30	3.11	2.26	3.22	2.22
23	Rib eye	3.42	3.34	2.84	2.35	3.21	1.94
70	"	3.29	3.30	3.36	2.38	3.22	2.28
75	"	4.37	4.30	4.22	3.04	4.11	2.96
Av.	"	3.69	3.65	3.47	2.59	3.51	2.39
23	Sirloin tip	3.52	3.58	2.76	....	3.49	1.74
70	"	2.90	2.88	2.26	....	2.79	1.44
75	"	2.81	2.81	2.23	....	2.64	1.44
Av.	"	3.08	3.09	2.42	....	2.97	1.54
Av.	Overall	3.36	3.35	3.00	2.43	3.23	2.05
18	Heart	3.74	3.75	2.90	....	2.47	1.82
737	"	3.28	3.23	2.97	....	2.33	1.62
Av.	"	3.51	3.49	2.94	....	2.40	1.72

[a] Using Drabkin's (1950) extinction coefficient for cyanmetmyoglobin (check method).
[b] Using Poel's (1949) method.
[c] Using the method of Shenk *et al.* (1934).
[d] Using the method of Ginger *et al.* (1954).

Quantitative Determinations of Pigments. Muscles from various regions of beef carcasses were used in the comparison of methods for determining meat pigments so as to provide more variation in pigment concentrations. The number of samples analyzed was too small to make it possible to draw definite conclusions concerning between-muscle variations of myoglobin and hemoglobin content, although the data in table 1 indicate some differences.

Determination of pigment content by conversion of the pigments in the muscle extracts to cyanmet- derivatives served as a check method against which total pigment estimates by the other methods were compared. This method is advantageous for determining total pigment concentrations since the derivative is simply prepared, is very stable, and the wave lengths of maximum spectral absorption (540 mμ) of the component pigments are the same, thereby reducing possible sources of error. The

slight difference in extinction coefficients for CNMMb and CNMHb at wave length 540 mμ does not cause an appreciable error in total pigment estimation.

The carbon monoxide conversion method provided the most accurate estimate of total pigment when compared with the check method (table 1). The percentage hemoglobin of the total pigment in skeletal muscle averaged about 3%, which is within the range of values found by Shenk *et al.* (1934) for beef rib eye (0 to 19%) and slightly less than that reported by Lawrie (1950) for horse rib eye (5.4%). However, later results from

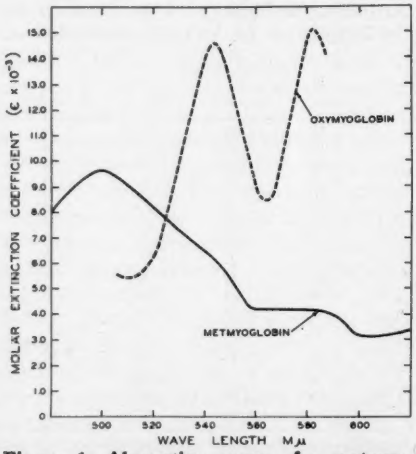

Figure 1. Absorption curves for metmyoglobin (pH=7.0) and oxymyoglobin.

over 150 beef rib eye extracts have varied as high as 18% hemoglobin and averaged approximately 5%. The percentage hemoglobin of the total pigment extracted from the heart samples averaged 30% and is lower than the average value of 49.6% reported by Lawrie (1950) for horse heart.

Values for total pigment, computed by the Shenk *et al.* (1934) method, were about 11% lower than those of the check method. Also, the percentage of myoglobin in skeletal muscle extracts averaged about 68, hemoglobin constituting 32% of the total pigment. DeDuve (1948) and others have doubted the validity of the assumption that all of the myoglobin is in the oxygenated state when using the method of Shenk *et al.* (1934), due to the ease with which myoglobin is auto-oxidized. A spectral curve of metmyoglobin (figure 1) was determined and the result was very similar to that reported by Bowen (1949). Also, a spectral curve of oxymyoglobin, based on Bowen's extinction coefficients, is included in figure 1 for the purpose of comparing the absorption spectra of the two compounds. In-

spection of the curves indicated that absorption due to metmyoglobin is decreasing sharply in the wave length vicinity of 542 mμ. This is the wave length from which total pigment values are computed by the Shenk *et al.* (1934) method; therefore, oxidation of myoglobin probably accounts for the lower values determined by this method in the present study. At wave length 580 mμ absorption due to metmyoglobin is lower still. If it is assumed that myoglobin was more completely oxidized than hemoglobin, this may account for the high percentage of hemoglobin calculated, since the ratio of optical densities at wave lengths 577 and 582 mμ is used to calculate the relative proportions of the two pigments.

TABLE 2. DETERMINATIONS OF MYOGLOBIN AND HEMOGLOBIN IN SOLUTION MIXTURE OF THE PURIFIED PIGMENTS BY THE CARBON MONOXIDE CONVERSION METHOD

Proportions of pigment added		Observed		Total pigment observed
Myoglobin	Hemoglobin	Myoglobin	Hemoglobin	
%	%	%	%	%
95	5	94.8	5.2	99.1
90	10	95.2	4.8	98.1
80	20	78.1	21.9	94.4
70	30	69.1	30.9	93.5
60	40	58.0	42.0	91.0
50	50	50.3	49.7	94.5
40	60	41.6	58.4	97.4
30	70	30.1	69.9	99.4
20	80	15.6	84.4	99.0
10	90	9.3	90.7	99.4

The concentration of myoglobin in the extracts was determined by a third method, that of Ginger *et al.* (1954), which involves quantitative removal of hemoglobin from the solution. The myoglobin values recorded in table 1 are lower than the average value of 3.7 mg./gm. of beef skeletal muscle found by Ginger *et al.* (1954). However, it should be noted that complete extraction of the pigment was attempted in the present study; whereas, Ginger *et al.* (1954) extracted only once with a 1:1 ratio of water:meat and assumed an equal amount of pigment to be left in the residue. Myoglobin values determined by the Ginger *et al.* (1954) method represented 69% of the total pigment concentration by the check method. Therefore, it was assumed that the difference, 31%, represented the proportion of hemoglobin in the extract. This result is similar to that found by Craig *et al.* (1959) who, by using a somewhat analogous procedure to that of the present work, found total pigment from the oxy- compounds and myoglobin by the Ginger *et al.* (1954) method. The difference in pigment concentrations determined by the two methods averaged 38% and represented

the percentage of hemoglobin. These percentages of hemoglobin in skeletal muscle extracts are considerably higher than those reported by others. Therefore, it appears very likely that in the present study some of the myoglobin was lost while attempting to remove the hemoglobin from solution by the Ginger *et al.* (1954) method. Nevertheless, even though myoglobin values were lower by this method than those by the carbon monoxide method, the results are generally relative. Moreover, myoglobin values determined by the oxy- and cyanmet- methods are quite similar. However, it is possible that both of these determinations were low, the former due to oxidation of myoglobin and the latter due to loss of myoglobin from the extract.

Solution Mixtures of Myoglobin and Hemoglobin. Since the carbon monoxide conversion method compared so closely with the check method on total pigment values, it was thought desirable to make a further investigation to affirm the validity of the method for estimating percentages of the pigments. Values obtained for the analyses of the solution mixtures are recorded in table 2. They indicate that the percentages of the pigments were closely measured except for the 90 and 20% levels of myoglobin. This variation was probably due to experimental error rather than the method. The last column of table 2 refers to the percentage of the total pigments in the known solutions that was calculated as total carbonyl pigments by the Poel (1949) method. These results indicated further that total pigment can be closely estimated by this method. However, there was some deviation of observed total pigment from the actual concentrations within the range of 50 to 80% myoglobin for which explanation is not apparent at present.

Molar extinction coefficients for MbCO and HbCO were determined for reassurance that the saturation technique was resulting in complete conversion of the pigments to the carbonyl compounds. The coefficients for MbCO at wave lengths 538 and 568 mμ were 14.9×10^3 and 12.1×10^3, respectively, while those for HbCO at these wave lengths were 14.9×10^3 and 14.8×10^3, respectively. Poel's (1949) extinction coefficients for MbCO at wave lengths 538 and 568 mμ are 14.8×10^3 and 11.8×10^3, respectively, while those for HbCO are 14.8×10^3 and 14.5×10^3, respectively.

From the foregoing results it appears that conversion of hemoglobin and myoglobin to carbon monoxide compounds after fresh reduction is a reliable analytical procedure for simultaneous determinations of these meat pigments. This method does not involve the quantitative separation of the pigments and it eliminates the error due to the oxidation of myoglobin which is encountered in the Shenk *et al.* (1934) method. The most difficult part of the procedure is in obtaining perfectly clear solutions for spectrophotometric readings. This problem is alleviated to a large extent by use of a suitable buffer extraction medium. Also, a less vigorous means of saturating the solution with carbon monoxide, such as the rotating tonometer device used by Poel (1949), may be of value.

Summary

Several methods were used to estimate quantitatively the myoglobin and hemoglobin concentration in beef muscle extracts. Of the methods used, determinations based on the conversion of these pigments in muscle extracts to carbon monoxide compounds provided the most favorable results. This method was tested with solution mixtures of myoglobin and hemoglobin of pre-determined concentrations. The total pigment concentration, as well as percentages of the two component pigments, were in close agreement with the values of the test solution mixtures.

Literature Cited

Bowen, W. J. 1949. The absorption spectra and extinction coefficients of myoglobin. J. Biol. Chem. 179:235.

Bowen, W. J. and H. J. Eads. 1949. Effects of 18,000 feet simulated altitude on the myoglobin content of dogs. Am. J. Physiol. 159:77.

Craig, H. B., T. N. Blumer and E. R. Barrick. 1959. Effect of several combinations of grass and grain in the ration of beef steers on the color characteristics of lean and fat. J. Animal Sci. 18:241.

DeDuve, C. 1948. A spectrophotometric method for the simultaneous determination of myoglobin and hemoglobin in extracts of human muscle. Acta Chem. Scand. 2:264.

Drabkin, D. L. 1950. The distribution of the chromoproteins, hemoglobin, myoglobin and cytochrome C in the tissues of different species, and the relationship of the total content of each chromoprotein to body mass. J. Biol. Chem. 182:317.

Drabkin, D. L. and J. H. Austin. 1935. Spectrophotometric studies. II. Preparation from washed blood cells; nitric oxide hemoglobin and sulf-hemoglobin. J. Biol. Chem. 112:51.

Ginger, I. D., G. D. Wilson and B. S. Schweigert. 1954. Biochemistry of myoglobin. Quantitative determination in beef and pork muscle. Agr. and Food Chem. 2:1037.

Lawrie, R. A. 1950. Some observations on factors affecting myoglobin concentration in muscles. J. Agr. Sci. 40:356.

Poel, W. E. 1949. Effect of anoxic anoxia on myoglobin concentration in striated muscle. Am. J. Physiol. 156:44.

Shenk, J. H., J. L. Hall and H. H. King. 1934. Spectrophotometric characteristics of hemoglobins. I. Beef blood and muscle hemoglobins. J. Biol. Chem. 105:741.

Singer, K., B. Angelopoulos and B. Ramat. 1955. Studies on human myoglobin. I. Myoglobin in sickle cell disease. Blood, The Journal of Hematology. 10:979.

Watson, R. H. 1935. Some observations on the estimation of muscle haemoglobin. Biochem. J. 29:2114.

EFFECT OF ALFALFA PASTURE BLOAT ON CERTAIN BLOOD COMPONENTS OF CATTLE [1]

L. R. BROWN,[2] R. S. ALLEN, R. H. JOHNSON[3] AND N. L. JACOBSON

Iowa State University, Ames

RESEARCH dealing with the effect of bloat on blood composition has not been extensive. Shinozaki *et al.* (1955) produced bloat in goats by obstructing the esophagus and observed the following effects on composition of the blood: increase in leucocytes, sugar and lactic acid; no effect upon ketones and non-protein nitrogen. Jackson *et al.* (1959) found an increase in plasma cholesterol levels associated with bloat among cattle grazing alfalfa pasture. Methemoglobin and total hemoglobin apparently are not related to bloat (Moore and Dracy, 1959). Preliminary reports indicating changes in certain blood components due to bloat have been presented by Brown *et al.* (1958, 1959).

The first phase of the present study was undertaken to determine the effect of bloat on blood ammonia, blood non-protein nitrogen, total blood phosphorus, plasma inorganic phosphorus, plasma lipid phosphorus and hematocrit values of cattle grazing alfalfa. In the second phase the changes in blood levels of ammonia, non-protein nitrogen, urea, total phosphorus, plasma inorganic phosphorus and plasma lipid phosphorus resulting from the consumption of alfalfa pasture were determined.

Experimental

During the 1958 and 1959 grazing seasons, young beef and dairy cattle (35 animals each year, mostly yearlings) were permitted to graze good quality alfalfa pasture for two 3-hour periods daily. Blood samples were taken from the jugular veins of bloated animals soon after bloat was rated 3 or more, on the scale described previously by Johnson *et al.* (1958). When possible, a sample of blood was taken from a non-bloated animal at about the same time as the sample from each bloated animal. Since more bloat usually was experienced during the evening grazing period, more of the samples were collected at that time. Usually, samples were taken from no more than six animals (three bloated and three non-bloated) during a single grazing period. Immediately after collection in flasks containing potassium oxalate, 5 ml. of whole blood (for nitrogen analyses) were added to 5 ml. of cold 20% trichloracetic acid, mixed, and stored in an ice bath. In the laboratory these samples were centrifuged, the supernatants were filtered and ammonia nitrogen (NH_3-N) analyses of the filtrates were

[1] Journal Paper No. J-3876 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 1267. Supported in part by funds provided by Regional Project NC-27.

[2] Present address: Department of Animal Industries, University of Connecticut, Storrs.

[3] Present address: Dawe's Laboratories, Inc., Chicago, Illinois.

completed within 48 hours. Previous results indicated that NH_3-N values in the filtrates did not change during this period of storage in the refrigerator. Non-protein nitrogen (NPN) determinations were made (1958 only) after the samples had been stored for several weeks.

In early 1958, NH_3-N was determined by a microdiffusion technique (Rose Brown *et al.*, 1957); later the method of Nathan and Rodkey (1957) was employed. During 1959, the analytical method was a modification of the Conway (1958) procedure. The method of Shahani and Sommer (1951) for the determination of NPN in milk was adapted for determination of blood NPN. Blood urea was determined by the direct nesslerization method of Koch and Hanke (1953).

TABLE 1. BLOOD AMMONIA, BLOOD NON-PROTEIN NITROGEN AND HEMATOCRIT VALUES IN BLOATED AND NON-BLOATED CATTLE

Condition of animals	Ammonia nitrogen	Non-protein nitrogen	Hematocrit
	μg. N/ml.	mg. N/100 ml.	%
Bloated	6.02 (83)[a]	56.4 (23)	41.7 (63)
Non-bloated	5.98 (65)	56.5 (16)	40.7 (77)

[a] No. in parenthesis indicates no. of samples.

Oxalated blood for the phosphorus determinations was held in the ice bath until taken to the laboratory. An aliquot was analyzed for total phosphorus (Hawk *et al.*, 1954) and the remainder was centrifuged to obtain blood plasma. Lipoproteins were precipitated from plasma with 10% trichloroacetic acid and centrifuged in 30 ml. micro-kjeldahl flasks. The insoluble portion was used for determination of lipid phosphorus (Zilversmit and Davis, 1950) and the soluble portion for determination of inorganic phosphorus by the method of Fiske and Subbarow as outlined in Hawk *et al.* (1954). Hematocrit values were determined for blood samples taken in 1959.

Prior to the 1959 grazing season, blood samples were taken from 33 of the animals while receiving dry feed. The values for the various blood components then were compared with the values obtained after pasture feeding was initiated.

The data collected in the above analyses were evaluated statistically by analyses of variance (Snedecor, 1956).

During the latter part of the 1958 grazing season, limited observations were made on the effect of ingestion of alfalfa pasture upon the levels of blood NH_3-N, NPN, urea, and the various phosphorus components. Jugular blood samples were obtained from each animal at approximately 7, 8:30, 10 and 11:30 a.m. and 1:30, 3, 5:30 and 7 p.m. Grazing periods were from 7 to 10 a.m. and from 4 to 7 p.m.

Results and Discussion

A summary of the blood NH_3-N, blood NPN, and hematocrit values of bloated and non-bloated animals is presented in table 1. There were no significant differences between bloated and non-bloated animals in these observations. Peripheral blood NH_3-N levels appear to be maintained in the body within very narrow limits; Lewis *et al.* (1957) reported that, in sheep, rumen NH_3-N concentrations must exceed 84 mg. % before an increase in ammonia in the peripheral blood can be detected. According to the work of Brown (1959), rumen NH_3-N levels do not approach this level during bloat. Shinozaki *et al.* (1955) also observed no change in blood NPN associated with experimental production of bloat in goats.

A comparison of the levels of the various phosphorus components in bloated and in non-bloated animals appears in table 2, wherein 1958 and 1959 data are combined. All differences between bloated and non-

TABLE 2. LEVELS OF CERTAIN PHOSPHORUS COMPONENTS IN BLOOD OF BLOATED AND NON-BLOATED CATTLE

Condition of animals	Total blood P	Plasma inorganic P	Plasma lipid P
	mg./100 ml.		
Bloated	22.2 (92)[a]	9.44 (98)	6.33 (95)
Non-bloated	21.1 (90)	8.58 (115)	5.98 (114)
P[b]	<0.005	<0.005	<0.050

[a] No. in parenthesis indicates no. of samples.
[b] Probability levels for differences between samples from bloated and non-bloated animals.

bloated animals were significant statistically. During the 1958 season, the hematocrit values were not determined; thus it was not known whether the increase in blood phosphorus observed during that season was accompanied by a hemoconcentration. Hematocrit values during the 1959 season (table 1) demonstrate no appreciable difference associated with bloat. The differences between bloated and non-bloated animals in the blood phosphorus components were of essentially the same order in 1959 as in 1958, although somewhat larger in 1958.

Usually there is considerable variability in bloat susceptibility among animals within a herd, and the cattle used in the present study were no exception. Several of the animals did not bloat appreciably. Therefore, the data presented above contain blood values for several animals in the non-bloated state that do not have values in the bloated state. A summary of results considering only animals with value in both classifications is presented in table 3. When only these animals are considered, there is somewhat less difference between bloated and non-bloated animals than when all animals are included (table 2). This suggests possible differences in levels of blood phosphorus components associated with bloat susceptibility.

All animals were ranked for bloat susceptibility on the basis of individual

TABLE 3. BLOOD LEVELS OF CERTAIN PHOSPHORUS COMPONENTS FOR ONLY THOSE ANIMALS WITH BOTH BLOATED AND NON-BLOATED CLASSIFICATIONS

Condition of animals	Total blood P	Plasma inorganic P	Plasma lipid P
	mg./100 ml.		
Bloated	21.5 (83) [a]	9.25 (75)	6.09 (85)
Non-bloated	20.9 (45)	8.78 (54)	5.82 (54)
P [b]	>0.10	<0.05	>0.10

[a] No. in parenthesis indicates no. of samples.
[b] Probability levels for differences between bloated and non-bloated animals.

daily maximum bloat scores. Blood phosphorus values of the 14 animals most susceptible to bloat were compared to those of the 14 least susceptible to bloat; results of this comparison are presented in table 4. In the groups with either high or low bloat susceptibility, blood phosphorus values tended to be higher in animals in the bloated than in those in the non-bloated state. In the group with high bloat susceptibility, there were no significant differences in the blood phosphorus components between bloated and non-bloated animals, but in the low group plasma lipid phosphorus and plasma inorganic phosphorus were higher ($P<0.005$) in animals when bloated than when non-bloated. Bloated animals in the group with high susceptibility had somewhat higher ($P<0.10$) plasma inorganic phosphorus and significantly lower ($P<0.025$) plasma lipid phosphorus values than bloated animals in the group with low susceptibility. There were no real differences in any of the blood phosphorus values between non-bloated animals in the high and low groups.

During the 1959 season blood phosphorus values were determined for all animals when receiving dry feed (alfalfa hay *(ad libitum)* plus 4 lb. per animal per day of a concentrate mixture of corn, oats and soybean oil meal) and again when the animals were on alfalfa pasture; in both cases the animals were in the non-bloated state. In table 5 the blood phosphorus

TABLE 4. EFFECT OF BLOAT AND BLOAT SUSCEPTIBILITY ON VARIOUS PHOSPHORUS COMPONENTS OF THE BLOOD

Bloat susceptibility	Condition of animals	Total blood P	Plasma inorganic P	Plasma lipid P
		mg./100 ml.		
High	1. Bloated	21.8 (63) [a]	9.18 (63)	6.02 (63)
	2. Non-bloated	20.9 (31)	8.85 (42)	5.96 (43)
Low	3. Bloated	21.8 (7)	8.75 (10)	6.94 (11)
	4. Non-bloated	21.2 (54)	8.44 (64)	5.90 (61)
	P [b] 1 vs. 2	>0.10	>0.10	>0.10
	P 3 vs. 4	<0.10	<0.005	<0.005
	P 1 vs. 3	>0.10	<0.10	<0.025
	P 2 vs. 4	>0.10	>0.10	>0.10

[a] No. in parenthesis indicates no. of samples.
[b] P=Probability level.

TABLE 5. EFFECT OF BLOAT SUSCEPTIBILITY AND TYPE OF FEED ON MEAN BLOOD PHOSPHORUS COMPONENTS

Bloat susceptibility classification[a]	No. of animals	Total blood P, mg./100 ml.			Plasma inorg. P, mg./100 ml.			Plasma lipid P, mg./100 ml.		
		Dry feed	P[b]	Pasture	Dry feed	P[b]	Pasture	Dry feed	P[b]	Pasture
High	14	20.3	<0.10	20.8	7.46	<0.005	9.53	5.39	<0.10	5.66
P[c]		<0.10		<0.10	<0.10		<0.025	<0.050		<0.10
Low	14	20.8	<0.10	21.0	8.36	<0.10	8.69	4.60	<0.005	5.91
All animals[d]	33	20.8	>0.10	21.0	7.84	<0.005	8.97	5.05	<0.005	5.91

[a] None of the animals were bloated when blood samples for these analyses were taken.
[b] Probability level of difference in blood phosphorus components between animals on dry feed and animals on alfalfa pasture.
[c] Probability level of difference in blood phosphorus components between animals of high and of low bloat susceptibility.
[d] Includes animals in the above classifications plus five others.

values of the 14 animals most susceptible to bloat are compared to those of the 14 animals least susceptible to bloat. The "all animals" line in table 5, in addition to the above 28 animals, also includes values for five others which were not included in either susceptibility classification. Plasma phosphorus values of non-bloated animals on alfalfa pasture were significantly different than the values observed in the same animals on dry feed prior to the grazing season. On dry feed the ones most susceptible to bloat had relatively low levels of plasma inorganic phosphorus and high levels of plasma lipid phosphorus. Moreover, the changes in the group with high bloat susceptibility were quite different from those in the group with low bloat susceptibility. The former had much higher levels of plasma inorganic phosphorus on pasture than on dry feed, but showed little difference in plasma lipid phosphorus due to type of feed. On the other hand, the group with low bloat susceptibility exhibited little difference in plasma inorganic phosphorus associated with type of feed, but were much lower in plasma lipid phosphorus on dry feed than on pasture. Neither group had a difference in total blood phosphorus associated with bloat or type of feed. The observed differences may be indicative of metabolic disparities between bloat-susceptible animals and non-bloat-susceptible animals but the nature of these differences is not yet clear.

The data presented herein indicate that blood phosphorus (mainly plasma inorganic phosphorus) levels are higher in bloated animals than in non-bloated animals. This evidence supports the hypothesis of Lienert (1950) which proposes that the high concentration of phosphorus in the forage plus the high level of phosphatase in the rumen is a primary factor involved in bloat. On the other hand, it may be contrary to another hypothesis (Cooper, 1957), which proposes that phosphorus fertilization reduces bloat. It must be recognized that part of the differences observed in blood phosphorus levels may be due to stress during bloat but this would not explain adequately the differences observed among animals in the non-bloated state.

All data in the tables have been summarized and analyzed giving equal weight to all values regardless of the number of samples taken from each animal. A summary on an animal basis resulted in values of the same magnitude and, in all cases, differences in the same direction as the values reported. Statistical analyses of data in the latter summary resulted in somewhat lower levels of significance due to the smaller number of observations that could be used in the analysis of variance.

The effects of grazing alfalfa pasture on the levels of various blood components are summarized in figure 1. Each line represents an average of five animals and all determinations except NH_3-N were made on the same samples. The values for NH_3-N were determined at a different time with different animals. Although the forage used in this study was of good quality, it was not bloat provocative, probably because it was less lush and less abundant than forage that usually produced bloat. Blood

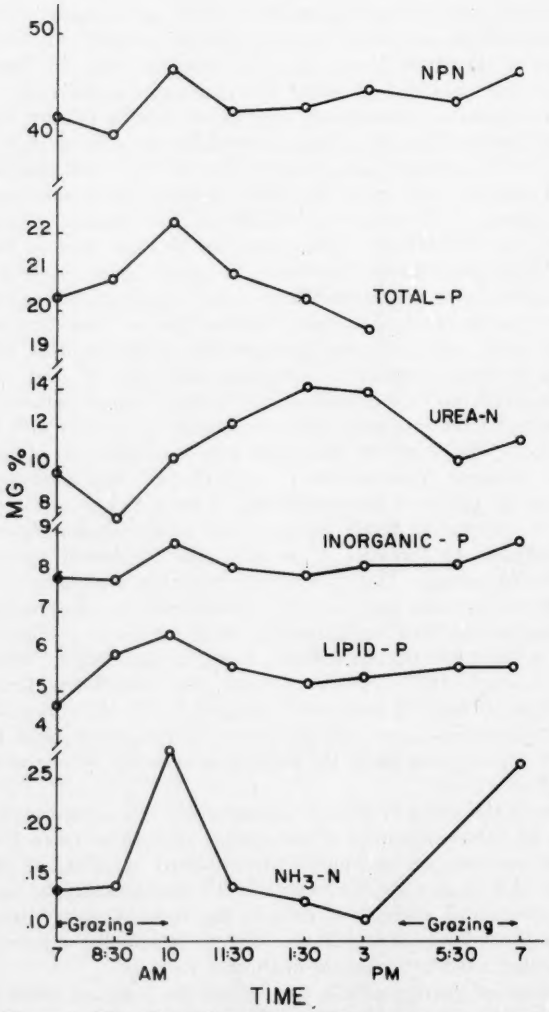

Figure 1. The effect of grazing alfalfa pasture upon certain blood constituents.

NH_3-N levels increased considerably during grazing; however, the peak values reached at the end of the grazing period were still less than the values usually found when bloat was prevalent (table 1). One and one-

half hours after the morning grazing, levels of blood NH_3-N had declined, approaching pre-grazing levels.

There was a slight increase in blood NPN due to grazing. There was very little increase in blood urea-N during the grazing period but there was a considerable increase for several hours following grazing. Total phosphorus, plasma lipid phosphorus and plasma inorganic phosphorus increased during grazing.

Additional observations indicated that relatively poor quality forage effected less response in the various blood components than the good forage.

Much more work is needed to elucidate fully the effect of ingestion of forage of various types and qualities on levels of certain blood components. Moreover, the possible relationship of level of these blood components to bloat needs further examination.

Summary

The effect of bloat on blood levels of various nitrogen and phosphorus components was studied in cattle grazing alfalfa pasture. There was no significant difference in blood NH_3-N, blood NPN, and hematocrit values between bloated and non-bloated cattle. Plasma inorganic phosphorus levels of bloated cattle were higher than those of non-bloated cattle. Levels of blood NH_3-N, NPN, urea, total phosphorus, plasma inorganic phosphorus, and plasma lipid phosphorus increased during grazing of good-quality alfalfa pasture.

Animals which were highly susceptible to bloat appeared to have higher levels of plasma inorganic phosphorus than animals which were less susceptible to bloat. Changing cattle from dry feed to alfalfa pasture caused changes in blood phosphorus components which were different in animals of high than in animals of low bloat susceptibility.

Literature Cited

Brown, L. R. 1959. Bloat and bloat prophylaxis and their relationship to certain properties of rumen ingesta and blood. Ph.D. Thesis. Iowa State University Library, Ames, Iowa.

Brown, L. R., R. S. Allen, R. H. Johnson and N. L. Jacobson. 1959. Effect of alfalfa pasture bloat on certain blood components. J. Animal Sci. 18:1559 (Abstract).

Brown, L. R., R. S. Allen, R. H. Johnson, N. L. Jacobson and P. G. Homeyer. 1958. Levels of various blood components in cattle grazing alfalfa pasture and their possible relationship to bloat. J. Animal Sci. 17:1188 (Abstract).

Brown, Rose H., G. D. Duda, S. Korkes and P. Handler. 1957. A colorimetric micromethod for determination of ammonia; The ammonia content of rat tissues and human plasma. Arch. Biochem. and Biophys. 66:301.

Conway, E. J. 1958. Microdiffusion Analysis and Volumetric Error (4th ed.). Macmillan Co., New York, N. Y.

Cooper, H. P. 1957. Relations of phosphorus deficiency to acute bloat in ruminants. Southeastern Vet. 8:120.

Hawk, P. B., B. L. Oser and W. H. Summerson. 1954. Practical Physiological Chemistry (13th ed.). The Blakiston Co., Inc., New York, N. Y.

Jackson, H. D., R. A. Shaw, W. R. Pritchard and B. W. Hatcher. 1959. Blood changes of cattle during bloat and effects of the alfalfa forage *in vitro*. J. Animal Sci. 18:158.

Johnson, R. H., L. R. Brown, N. L. Jacobson and P. G. Homeyer. 1958. Effectiveness and practicability of some oils, penicillin, n-decyl alcohol, and lecithin in the control of alfalfa bloat. J. Animal Sci. 17:893.

Koch, F. C. and M. E. Hanke. 1953. Practical Methods in Biochemistry (6th ed.). The Williams and Wilkins Co., Baltimore, Maryland.

Lewis, D. K. J. Hill and E. F. Annison. 1957. Studies on the portal blood of sheep. 1. Absorption of ammonia from the rumen of sheep. Biochem. J. 66:587.

Lienert, E. 1950. Die pharmakotherapie der pansentympanie mit besonderer berücksichtigung der pharmakodynamik des tartarus stibiatus auf den pansen. Wiener Tierarztl. Monatschr. 37:758.

Moore, C. L. and A. E. Dracy. 1959. Methemoglobin and total hemoglobin values in bloated cattle. J. Dairy Sci. 42:914 (Abstract).

Nathan, D. G. and F. L. Rodkey. 1957. A colorimetric procedure for the determination of blood ammonia. J. Lab. and Clin. Med. 49:779.

Shahani, K. M. and H. H. Sommer. 1951. The protein and non-protein nitrogen fraction in milk. I. Methods of analysis. J. Dairy Sci. 34:1003.

Shinozaki, K., A. Yuyama and H. Sugawara. 1955. Studies on the experimental ruminant tympany. I. Blood and clinical changes resulting from obstructing the esophagus of goat. J. Fac. Agr. Iwate Univ. 2:308.

Snedecor, G. W. 1956. Statistical Methods (5th ed.). Iowa State University Press, Ames, Iowa.

Zilversmit, D. B. and A. K. Davis. 1950. Microdetermination of plasma phospholipids by trichloroacetic acid precipitation. J. Lab. and Clin. Med. 35:155.

A TECHNIQUE FOR ASSAY OF GOITROGENS IN FEED [1]

B. N. PREMACHANDRA AND C. W. TURNER

University of Missouri, Columbia

GOITROGENS have been employed in livestock and poultry for fattening purposes (Hill, 1953; Winchester and Andrews, 1953). Encouraging feed lot results with cattle have been obtained recently with tapazole (Trenkle and Burroughs, 1959). In addition, another new drug, carbimazole, is being tried for similar purposes. However, the techniques so far available for detection of goitrogenic residues in meat tissues are not sufficiently sensitive to detect minute amounts, although Raun *et al.* (1958), by their technique, found insignificant amounts of goitrogenic residue when tapazole was fed up to 800 mg./day for 79 days in beef animals.

The purpose of this communication is to describe a technique whereby minute amounts of goitrogens can be detected in animal feed.

Materials and Methods

Adult female rats of Sprague-Dawley-Rolfsmeyer strain weighing 200–300 gm. were kept under conditions of uniform temperature (78±1° F.) in a room artificially illuminated during normal daylight hours for 1–2 weeks prior to investigation. In some of the original experiments rats were fed ground Purina Lab. Chow. In the later experiments Purina Chow was replaced by Remington's low iodine diet (Remington, 1937) in order to enhance the low iodine uptake that is generally prevalent in rats. The structural formula of the two goitrogens employed in the present study, viz., tapazole and carbimazole, have been presented and their comparative effectiveness evaluated recently in cattle (Premachandra *et al.*, 1960). The goitrogens were mixed with the feed through a series of premixes.

Each rat was injected with 1–2 μc. carrier-free I^{131} and 24-hour external thyroid counts were made by first anaesthetizing each animal with ether, then placing it on a lead plate with its thyroid region over a scintillation probe. Measurements of thyroidal radioactivity were made with scintillation counter (Nuclear Chicago Model DS-5) connected to a Nuclear Chicago rate meter (Model 1620A).

In the earlier experiments tapazole or carbimazole was mixed with powdered Purina Lab. Chow at various concentrations, viz., .001, .002,

[1] Contribution from Mo. Agr. Exp. Sta. Department of Dairy Husbandry. Journal Series No. 2163. Approved by the Director.

[2] Aided in part by grant from U. S. Atomic Energy Commission, Contract No. AT(11-1)-301. The supply of tapazole from Lilly Laboratories (Eli Lilly and Co., Indianapolis) and carbimazole from Denver Chemical Manufacturing Co. (Stamford, Connecticut) is gratefully acknowledged.

.003, .005, .01% (corresponding to 10, 20, 30, 50, and 100 ppm.) and fed for 4 days. On the 4th day 1–2 μc. I^{131} was injected intraperitoneally and 24-hour thyroidal-I^{131} uptake determined. Goitrogens, by preventing the synthesis of thyroxine, inhibit the uptake of I^{131} and the effectiveness of a goitrogen is, therefore, shown by total blockage or reduced uptake of I^{131} in comparison with controls. A similar procedure was followed in later experiments when a low iodine diet was used.

In conjunction with uptake measurements, release rate of I^{131} was also employed in detecting and comparing the effectiveness of goitrogens (Premachandra *et al.*, 1960).

Thyroidal-I^{131} measurements were made 24 hours after I^{131} injection for 4 days and the normal rate of release of I^{131} (k′ 4) determined. Goitrogens mixed with the feed at various concentrations were fed, commencing on day 4, for a period of 4 days and a second rate of release under the goitrogen (k″ 4) was obtained and compared with previous normal release rate. Goitrogens, by preventing recycling of I^{131} from metabolized hormone-I^{131} increase the normal thyroidal-I^{131} release rate (Pipes *et al.*, 1958). The least amount of tapazole or carbimazole that significantly increased the normal rate of release of I^{131} were compared.

Results

When various concentrations of goitrogen are mixed with Purina Lab. Chow, the lowest amount of tapazole that could be successfully detected ($p<.01$) was at 0.003% concentration (or 30 ppm.) as shown by reduced

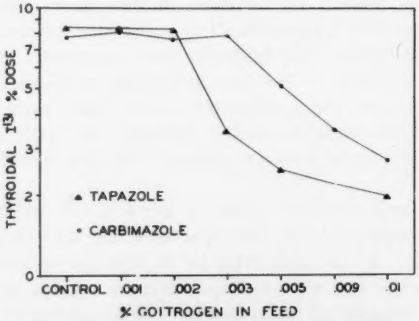

Figure 1. Effect of various concentrations of goitrogens in feed on 24-hr. uptake of I^{131} in rats. Tapazole at a concentration of 0.003% (30 ppm.) reduced I^{131} uptake in comparison with controls, whereas 0.005% (50 ppm.) concentration was required for carbimazole to produce a similar effect. Each point on the graph represents an average of at least 37 rats.

TABLE 1. EFFECT OF MINUTE AMOUNTS OF GOITROGENS ON I^{131} RELEASE RATES IN THYROID GLAND OF RATS

No. of rats	Concentration of goitrogen in feed, %	Thyroidal-I^{131} release rates[a]				
		Normal (k'4)	Carbimazole (k''4)	No. of rats	Normal (k'4)	Tapazole (k''4)
40	0.0001	0.00096±.00011	0.0010 ±0.0009	36	0.0064 ±.00084	0.0066±.0001
40	0.001	0.00276±.0005	0.00243±0.0008	38	0.00252±.001	0.0026±.0006
40	0.002	0.00186±.00057	0.00190±0.0005	41	0.00168±.0002	0.0017±.0006
40	0.003	0.00064±.0001	0.00074±0.0001	40	0.0082 ±.001	0.015 ±.002*
38	0.005	0.0068 ±.0003	0.010 ±0.001*	39	0.0063 ±.0009	0.010 ±.006*
42	0.01	0.0059 ±.001	0.012 ±0.002**	42	0.0045 ±.0006	0.0106±.0001**

[a] It is seen that the rate of release of I^{131} begins to increase at concentrations of 0.003% for tapazole and 0.005% for carbimazole in feed. Below these concentrations rate of release is not affected.
* $P<.05$.
** $P<.01$.

I^{131} uptake in comparison with controls (figure 1). Carbimazole at 0.005% concentration (or 50 ppm., $p<.05$) could be detected under similar circumstances. With increasing concentrations of tapazole and carbimazole, I^{131} uptake was progressively reduced. However, it has been observed also that differences in I^{131} uptake are not appreciable if the concentration of goitrogens in feed are spaced too closely. Tapazole always seemed to be 1½–2 times more potent than carbimazole in reducing I^{131} uptake at equivalent low concentrations. At higher concentrations of goitrogens in feed, the difference in the magnitude of inhibition of I^{131} uptake became progressively reduced (figure 1).

Similar findings were noted when I^{131} release rate was used to compare the effectiveness of the two goitrogens. Carbimazole and tapazole at concentrations of 0.005% and 0.003% in feed effectively increased the rate of release of I^{131} from the thyroid gland, indicating thereby that detection is possible at these concentrations (table 1). Once again tapazole was found to be twice as potent as carbimazole in increasing the rate of I^{131} release.

The uptake of I^{131} is increased markedly under Remington's low iodine diet, 50–70% of administered dose (figure 2). Under these conditions tapazole, at concentrations of 0.00005% ($.05<p<.2$) and 0.0001% ($.05<p<.1$), and carbimazole at 0.0001% ($.05<p<.1$) in feed reduced I^{131} uptake in comparison with controls, greater inhibition being observed at higher concentrations. The use of the low-iodine diet, therefore, greatly increased the sensitivity of the technique from 30 ppm. to 0.5–1.0 ppm. In passing, it may be mentioned that no particular advantage was seen by making a 48-hour thyroidal-I^{131} uptake in comparison with a 24-hour uptake.

Discussion. The lowest concentration of goitrogen that could be detected when mixed with Purina Lab. Chow was about the same whether the uptake or release of I^{131} was employed as an index of effectiveness, indicating, thereby, that the phenomenon involved in both measurements is the same. However, the uptake of I^{131} in rats is generally low. Hence,

reduced I^{131} uptake due to goitrogen treatment is rather difficult to distinguish from the normally low uptakes observed in our laboratory. With Remington's low-iodine diet, the base for normal uptake is very greatly enhanced and any inhibition of I^{131} uptake due to a minute concentration of goitrogen can be readily detected.

Tapazole was 1½–2 times more potent than carbimazole at lower concentrations but both were of about equal potency at higher concentrations. This indicates that once the enzyme system responsible for oxidation

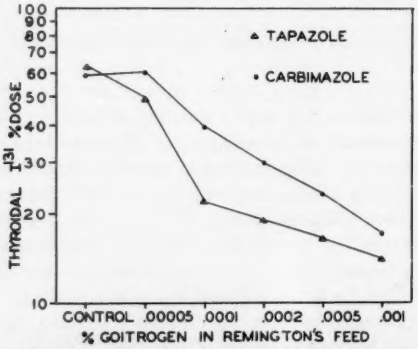

Figure 2. Effect of various concentrations of goitrogens in feed (low iodine diet) on 24-hr. I^{131} uptake in rats. It will be seen that the normal uptake of I^{131} is greatly enhanced. The reduced uptake of I^{131} is noted beginning at concentrations of 0.0005% (½ ppm..) for tapazole and 0.0001% (1 ppm.) for carbimazole. Each point on the graph represents an average of at least 35 rats.

of I_2 is saturated with goitrogens additional amounts will have no meaning in terms of eliciting the physiological response (in this case, inhibition of I^{131} uptake). For example, at 100 ppm. in feed, both carbimazole and tapazole are about equipotent in reducing I^{131} uptake (figure 1). The finding that at low concentrations tapazole was twice as potent as carbimazole is the reverse of what has been reported in cattle where blocking doses were compared (Premachandra *et al.*, 1960). Nevertheless, the difference in potency between tapazole and carbimazole seldom exceeds by a factor of 2, in general agreement with others (Bartels, 1953; MacGregor and Miller, 1953).

The fact that carbimazole and tapazole at 0.00005–0.0001% in feed can be detected affords a sensitive technique by which the tissues of goitrogen-fed animals can be assayed for presence of minute amounts of

residues. I^{131} uptake technique has advantage over the release rate method in minimizing duration of the assay procedure.

Summary

An assay procedure has been described which can be used to detect minute amounts (0.5–2 ppm.) of residues in tissues of goitrogen-fed animals. The technique described in rats consists in determining 24-hour I^{131} uptake after feeding the goitrogen (or tissues) for a period of 4 days and then comparing it with control I^{131} uptakes. A low-iodine diet, by enhancing I^{131} uptake, increased the sensitivity of the assay technique. By this method, tapazole at 0.00005–0.0002% (½–2 ppm.) and carbimazole at 0.0001–0.001% (1–10 ppm.) in low iodine feed could be detected as shown by reduced I^{131} uptake in comparison with controls.

Literature Cited

Bartels, E. C. 1953. Clinical experience with a new antithyroid drug, 2-carbethoxythio-1-methylglyoxaline. J. Clin. Endocr. 13:1305.

Hill, F. W. 1953. Thyroprotein and antithyroid drugs in poultry feeding. Nat. Acad. Sci. Nat. Res. Council, Pub. 266.

MacGregor, A. G. and H. Miller. 1953. The antithyroid activity of 2-carbethoxythio-1-methylglyoxaline. Lancet 1:881.

Pipes, G. W., B. N. Premachandra and C. W. Turner. 1958. A technique for estimation of the effectiveness of goitrogens in cattle. J. Animal Sci. 17:227.

Premachandra, B. N., G. W. Pipes and C. W. Turner. 1960. Comparative goitrogenic activity of tapazole and carbimazole in cattle. J. Animal Sci. 19:553.

Raun, N., E. Cheng, A. Raun, S. Balloon and P. Homeyer. 1958. Radioactive tracer technique for assaying goitrogenic residues in beef tissues. J. Animal Sci. 17:1227 (Abstract).

Remington, R. E. 1937. Improved growth in rats on iodine deficient diets. J. Nutr. 13:223.

Trenkle, A. and W. Burroughs. 1959. Liveweight gain stimulation in beef cattle with methimazole administration with observations on growth hormone secretion. J. Animal Sci. 18:1545 (Abstract).

Winchester, C. F. and F. N. Andrews. 1953. Some uses of drugs and hormones in beef cattle, sheep and swine husbandry. Nat. Acad. Sci. Nat. Res. Council, Pub. 266.

EFFECT OF TEMPERATURE UPON THE NUTRITIVE VALUE OF ARTIFICIALLY DRIED HAY [1, 2]

J. W. Bratzler, E. Keck, Jr. and R. R. Yoerger [3]

Pennsylvania Agricultural Experiment Station, University Park

DURING the past few years elaborate hay drying systems have been developed and are being used rather extensively, in some sections of the United States, to complete the drying of either baled or chopped hay in which the moisture content has been reduced by field curing to approximately 40 or 45%. The use of temperatures higher than 135° F. has been avoided by most designers of these hay drying systems, and by those interested in promoting their use by farmers, because of the possible detrimental effects upon nutritive value of the dried forage. However, it has been conceded, generally, that the efficiency of these hay drying systems could be increased significantly if it were permissible to use higher drying temperatures.

Hart, Kline, and Humphrey (1932) found that the nutrients of green alfalfa exposed to temperatures of 480° to 535° C. (896 to 995° F.) in a Koon-type drier for 40 seconds were no less digestible than those of similar alfalfa dried in the field. Woodman and his associates (1930) concluded that the high nutritive value of young pasturage was not depressed appreciably by artificial drying with steam at 100° C. (212° F.). Pasture grass dried by direct heat in a kiln chamber at 115° C. (239° F.), for 3 hours was only slightly less digestible than similar herbage dried at the temperature of steam. They reported that the grass, while in the chamber, at no time reached a temperature above 90° C. (194° F.).

Materials and Methods

Second cutting alfalfa was harvested at the full-bloom stage with a direct cut-forage harvester at the same time of day on four successive days. Approximately 600 lb. of the freshly chopped forage were placed immediately each day into the drier. The four lots of forage were dried at temperatures of 200°, 165°, 135°, and 110° F. on August 12, 13, 14, and 15, respectively. The freshly chopped forage was spread out evenly on the floor of the drier to a depth of approximately 12 inches. The air was heated by passing it over a heat exchanger for which high pressure steam was used as the source of heat and was then introduced through a false floor of the drier and through the fresh forage. The temperature of the heated air was thermostatically controlled in which the variation in

[1] Authorized for publication on May 23, 1960 as Paper No. 2462 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] Departments of Animal Nutrition and Agricultural Engineering.

[3] Present address: Department of Agricultural Engineering, University of Illinois, Urbana, Illinois.

temperature was limited to approximately ±5° F. Virtually complete dehydration of the fresh forage was found to have occurred when the temperature of the exhausted air was within 5 degrees of the temperature of the air as it was introduced into the mass of hay. Each lot of hay was stored in large burlap bags until it was fed to sheep during conventional digestion trials. A group of four sheep was used in a 4x4 Latin square design type of experiment in which each sheep received 800 gm. per day of each lot of forages. A seven-day preliminary period and a ten-day collection period were used throughout the experiment. Samples of each lot of dried forage were subjected to complete proximate analyses while the samples of feces were analyzed only for their contents of dry matter, crude protein, and gross energy.

TABLE 1. CHEMICAL COMPOSITION OF HAYS USED IN THE EXPERIMENT (DRY MATTER BASIS)

Drying temperature	Crude protein	Crude fiber	Ether extract	Nitrogen-free extract	Ash	Energy
	%	%	%	%	%	cal./gm.
110° F.	16.62	35.92	2.46	38.82	6.18	4587
135° F.	15.90	31.69	2.72	43.18	6.51	4571
165° F.	16.44	31.05	2.73	43.28	6.50	4577
200° F.	16.50	31.66	2.76	42.31	6.77	4550

Results and Discussion

Periods of time required for drying of the hay at the temperatures of 110°, 135°, 165°, and 200° F. were: 20, 12, 7½, and 5½ hours, respectively. No discoloration was observed in any of the four lots of dried hay. As was to be expected, each increase in drying temperature resulted in a significant decrease in the period of time required to dry the particular lot of hay.

The results of the complete proximate analyses of the four lots of hay are presented in table 1. Differences in chemical composition are apparent with the lot of hay dried at 110° F. Crude fiber content is significantly higher while ether extract and nitrogen-free extract values are significantly lower when compared with the other three lots of hay. This would appear to indicate that the lowest drying temperature permitted respiration by the plant to continue and/or fermentation to occur and was reflected principally in an appreciable lowering of the nitrogen-free extract content of the hay.

Table 2 shows the apparent digestibility of dry matter, crude protein, and energy for the hays dried at the four temperatures. All values shown are averages of the values obtained on each of the four sheep used throughout the experiment. These data were treated statistically by the method of analysis of variance.

When the individual differences were examined with Tukey's HSD Test, it was found that: (1) the crude protein of the hay dried at 200° F. was slightly but significantly less digestible ($P<0.01$) than that of the hays dried at the three lower temperatures and (2) the dry matter and energy of the hays dried at 135° F. and 165° F. were significantly more digestible ($P<0.05$) than those of the hays dried at either of the extreme temperatures.

The depression of the digestibility of the crude protein of forage has been previously reported by Watson and Ferguson (1932) who compared the digestibility of pasturage that had been dried at different temperatures in a band drier and a pneumatic-conveyor drier with fresh green herbage. In the band drier, at an inlet temperature of 200° C. (392° F.), the herbage was dried to 10% moisture in 20 minutes with no effect on the

TABLE 2. APPARENT DIGESTIBILITY OF ARTIFICIALLY DRIED SECOND CUTTING ALFALFA

Drying temperature	Dry matter	Crude protein	Energy
	%	%	%
110° F.	57.3	70.9	54.8
135° F.	59.3	70.6	56.8
165° F.	59.1	71.5	56.6
200° F.	58.1	69.2	55.3

digestibility of the various constituents, except on that of crude protein which was slightly depressed. With similar herbage, dried in the conveyor drier at a temperature of 600° C. (1112° F.) for 15 seconds, a depression of the digestibility of the constituents of the grass was noted, particularly the digestibility of the crude protein which was decreased markedly. Honcamp (1915) reported that artificial drying of grass at low temperatures caused no loss in the raw or digestible nutrients. When artificial drying was accomplished by hot fire gases, a considerable reduction of protein digestibility occurred. He did not, however, specify what temperatures were used.

Hodgson and associates (1935), using an experimental direct heat rotary single-drum drier, dried pasture herbage at outlet temperatures of 250°, 300°, 350°, and 400° F. Drying of the herbage was completed in from 3 to 5 minutes. These dehydrated grasses were then compared with the freshly cut pasture herbage as well as the sun-cured grass in digestion trials with sheep. The pasture grass dehydrated at 400° F. was the only dehydrated grass which exhibited a decrease of the apparent digestibility of the crude protein, dry matter, and nitrogen-free extract.

In the study reported here the slight but significant decline in the digestibility of the crude protein of the hay dried at 200° F. suggests that some denaturization of the protein fraction had occurred at this drying temperature. This decline is reflected also in the lower values obtained for

digestible dry matter and digestible energy when compared with the corresponding values obtained for the hays which had been dried at 135° F. and 165° F. The lower values obtained for digestible dry matter and digestible energy of the hay dried at 110° F., when compared with the corresponding values obtained for the hays dried at 135° F. and 165° F., indicate that a small but significant loss of the more digestible fractions of the forage had occurred as a result of the continuance of respiration of the plant and/or the occurrence of some fermentation.

Based on the results presented above, it is apparent that drying temperatures of 135° to 165° F., for relatively long periods of time, are the most desirable from the standpoint of maximum conservation of the nutrients contained in fresh forage. In the operation of wagon and batch hay drying systems the use of these higher temperatures will not only permit substantial recirculation of the heated air, but the rate of drying will be increased significantly and maximum conservation of the nutrients contained in the fresh forage will be obtained. The overall result should be a significant increase in the efficiency of these types of hay drying systems.

Summary

Four lots of second cutting alfalfa, harvested at the full bloom stage with a direct-cut forage harvester, were dried on successive days at temperatures of 110°, 135°, 165°, and 200° F. Each hay was fed in a 4x4 Latin square design type of experiment to a group of four sheep in conventional digestion trials.

Drying temperatures of 135° and 165° F. were superior to either of the extreme temperatures as judged by digestible dry matter and energy values. Hay dried at 200° F. was slightly lower in digestibility of protein than the hays dried at the three lower temperatures.

When hay drying systems use relatively long periods of time to complete the drying process, 5 to 20 hours, temperatures as high as 165° F. can be used safely without lowering the nutritive value of the dried forage.

Literature Cited

Hart, E. B., O. L. Kline and G. C. Humphrey. 1932. The effect of artificial drying on the availability of nutrients in alfalfa. J. Agr. Res. 45:507.

Hodgson, R. E., J. C. Knott, R. R. Graves and H. K. Murer. 1935. Effect of temperature of artificial drying on digestibility and availability of nutrients in pasture herbage. J. Agr. Res. 50:149.

Honcamp, F. 1915. Vergleichende Untersuchungen Uber Die Zusammensetzung Verdaulichkeit Von Frischen Gras, Naturlich Geworbenem und Durch Kunstliche Trocknung Gewonnenem Heu. Landw. Versuchs. Sta. 86:215.

Watson, S. J. and W. S. Ferguson. 1932. Investigations into the intensive system of grassland management. VIII. The comparative digestibility of fresh and artificially dried grass. J. Agr. Sci. 22:235.

Woodman, H. E., J. W. Bee and G. Griffith. 1930. Nutritive value of pasture. V. Pasture grass conservation: The influence of artificial drying on the digestibility of pasture herbage. J. Agr. Sci. 20:53.

A METHOD OF ESTIMATING THE PERCENTAGE OF PROTEIN AND FAT IN THE EDIBLE PORTION OF STEER CARCASSES [1]

W. H. KENNICK AND D. C. ENGLAND [2]

Oregon Agricultural Experiment Station, Corvallis

THE preference of consumers for cuts of meat having a high percentage of desirable lean tissue, coupled with the financial loss to the meat industry resulting from excess fat, makes it essential that beef animals be produced with a high percentage of lean. It is important that an economically feasible method of estimating the proportions of fat and lean be available to research workers. Hankins and Titus (1939) concluded that the studies of meat animals are not complete without determinations of body composition.

The classical work of Lawes and Gilbert (1858) on the analysis of whole animal bodies has been followed by the use of ever smaller sample cuts (Lush, 1929; Hankins and Howe, 1946) for measures of the composition of the whole carcass. Extensive investigations by Hankins and Howe (1946) have dealt with the relationship of the physical and chemical composition of part of the beef carcass to the carcass as a whole and to other parts. Their work confirmed the adequacy of the 9-10-11th rib as a sample of the carcass upon which to base prediction equations.

The purpose of the research reported herein was to investigate the possibility of using a still smaller sample, as was done by Aunan and Winters (1952) in pork carcass studies, as a predictive measure of the protein and fat content of steer carcasses.

Materials and Methods

Data were collected over a two-year period on 80 carcasses from grade Hereford and Aberdeen Angus steers raised on several different ranches and finished on various levels of concentrate feeding. The carcass weights varied from 318 to 761 lb. with a mean of 518 lb. The carcasses graded from Standard to Choice.

The animals were slaughtered at a commercial abattoir. The normal commercial practices of taking warm carcass weights, shrouding the carcasses and chilling them at temperatures of approximately 32° F. for 48 hours before cutting were followed. The 9-10-11-12th rib cut from the right forequarter was purchased for experimental use.

Using a coring device (0.25 in. in diameter and 15 in. long) patterned after that of Aunan and Winters (1952), two pairs of probe samples were taken from each rib cut: one pair between the 8th and 9th ribs and one

[1] Technical Paper No. 1332. Oregon Agricultural Experiment Station.
[2] Department of Dairy and Animal Husbandry.

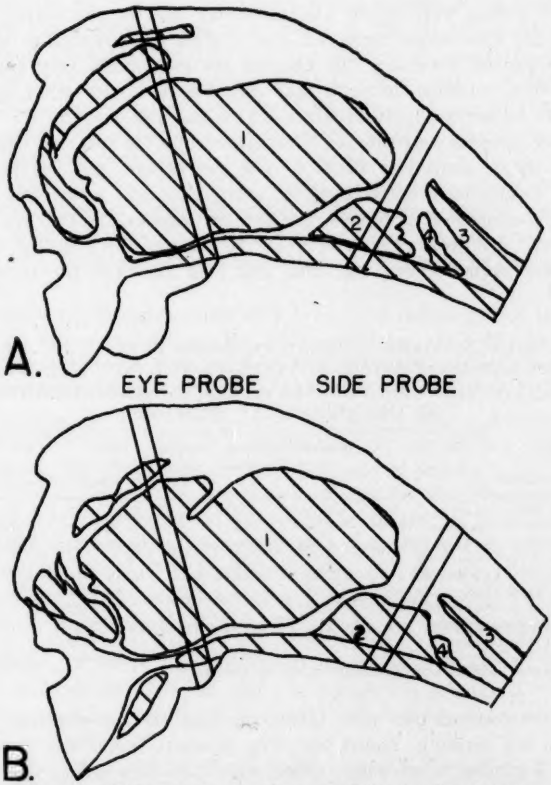

Figure 1. Cross section tracings of rib cuts taken between the 8th and 9th (A) and 10th and 11th (B) ribs showing the locations of the side and eye probes. Muscles: (1) Longissimus dorsi (2) Longissimus costarum (3) Latissimus dorsi (4) Obliquus abdominus externus.

pair between the 10th and 11th ribs. One of each of these two pairs of probes was taken through the deepest portion of the *longissimus dorsi* muscle and will hereinafter be referred to as the eye probe; the other of these two pairs of probes was taken through the center of the seam of fat which separates the *longissimus dorsi* and *longissimus costarum* muscles from the *obliquus abdominus externus* and *latissimus dorsi muscles* perpendicular to the rib and will hereinafter be referred to as the side probe. The location of these probes is illustrated in figure 1.

The location of these probes was chosen in an endeavor to sample the muscular tissues, the external fat and the intermuscular fatty tissues.

The fatty tissues were easily and uniformly cut by the coring device, however, the lean tissues were not, and a great deal of care in sampling the latter proved necessary. By keeping the instrument very sharp and using a slow rotating thrust it was possible to obtain what appeared visually to be a reasonably accurate cut of the lean tissue.

The core samples were physically separated into fat and lean tissues and weighed on an analytical balance. The percentage and weight of fat and lean tissues were determined for each individual probe and for the following combination of probes: the two side probes, the two eye probes, the side and eye probes taken between the 8th and 9th ribs, the side and eye probes taken between the 10th and 11th ribs and the four probes combined.

TABLE 1. SIMPLE CORRELATIONS* BETWEEN PREDICTIVE MEASURES AND THE FAT AND PROTEIN CONTENT OF THE BONELESS 9–10–11TH RIB CUT AND THE RANGES, MEANS AND STANDARD DEVIATIONS OF THE PREDICTIVE MEASURES

Predictive measures	Percent fat, r	Percent protein, r	Carcass weight r	Range	Mean	Standard deviation
Weight of fat in 8–9 eye probe	0.35	—.30	....	0.27–0.95	0.59	0.18
Weight of fat in 8–9 side probe	0.75	—.65	....	0.28–1.12	0.69	0.22
Weight of fat in 8–9 eye+side probe	0.69	—.59	....	0.60–2.07	1.28	0.11
Weight of fat in 10–11 eye probe	0.57	—.52	....	0.24–1.06	0.53	0.19
Weight of fat in 10–11th side probe	0.73	—.66	0.61	0.33–1.16	0.65	0.20
Weight of fat in 10–11 eye+side probe	0.77	—.70	0.59	0.62–2.21	1.18	0.11
Weight of fat in two eye probes	0.58	—.51	....	0.59–2.00	1.12	0.31
Weight of fat in two side probes	0.81	—.71	0.57	0.64–2.28	1.35	0.38
Weight of fat in four probes	0.81	—.72	0.54	1.48–4.28	2.46	0.65

* All correlation coefficients are statistically significant ($P<0.01$).

After the core samples were taken, the 12th rib was removed and the 9-10-11th rib carefully boned out. The boneless tissue was ground five times in a grinder fitted with a plate with 1/16-inch holes; the material was thoroughly mixed after each grinding and after the final grinding a sample was taken for chemical analyses. Crude protein and water of each sample were determined by A.O.A.C. methods and fat by modified Babcock method.

Results and Discussion

Simple correlation coefficients between (1) percentage of fat and (2) weight of fat in the probe sample with the fat and the protein content of the boneless 9-10-11th rib cut as determined by chemical analyses were calculated for individual probes and various combinations of the four probes and are presented in table 1. Weight of fat in the probe was found to be more highly correlated with chemical composition of the 9-10-11th-boneless rib cut than was percent of fat or of lean in the probe. The failure

of the percent of fat and lean in the probe sample to be more highly associated with percent of fat and protein in the boneless 9-10-11th rib cut probably resulted from difficulty in obtaining an accurate cut of the lean tissue. The fat was accurately cut and consequently its weight was a good indication of the composition of the edible portion of the carcass. Simple correlation coefficients between weight of fat in the probe samples and the chemical composition of the boneless 9-10-11th rib cut are presented in table 1. Since the weight of the carcass from which the probes were taken influences the weight of fat in the probes, carcass weight was included in the correlations investigated and these are also given in table 1, along with the ranges, means and standard deviations of the predictive measures.

The weight of the carcass not only influenced the weight of fat in the probes but was significantly ($P<0.01$) correlated with the percentage of fat and protein in the boneless 9-10-11th rib cut. The simple correlation coefficients between weight of carcass and percentage of fat and of protein in the boneless 9-10-11th rib cuts were 0.64 and —.65, respectively. Multiple correlation coefficients (R) of weight of fat in the two side probes and warm carcass weight with percent of fat and of protein in the boneless 9-10-11th rib cut were 0.88 and 0.86, respectively. The regression equations accounted for 78.09% of the variation in the fat and 73.50% of the variation in the protein content of the boneless 9-10-11th rib cut.

The multiple correlation coefficients were of sufficient magnitude to make their use in predicting the fat and protein content of the boneless 9-10-11th rib cut of practical value. The prediction equations are:

(1) Percent of fat in the boneless 9-10-11th rib cut=5.94+[11.49 ×total weight of fat in two side probes (in grams)]+[0.0274× warm carcass weight (in pounds)]. The standard error of the estimate was 2.16.

(2) Percent of protein in the boneless 9-10-11th rib cut=20.43— [2.02×weight of fat in the two side probes (in grams)]— [0.0064×warm carcass weight (in pounds)]. The standard error of the estimate was 0.71.

The prediction equations derived in this study were designed to predict the fat and protein content of the boneless portion of the 9-10-11th rib cut. The values derived by the use of these equations may be used in determining the relative degree of fatness or leanness of steer carcasses. In order to transform these predicted values to percentage of protein and fat in the edible portion of steer carcasses, the prediction equations derived by Hankins and Howe (1946) can be used. This will not add to the ability to detect differences between groups of steers but will serve principally as a standard method by which comparisons can be made.

To simplify this procedure the above prediction equations have been algebraically combined with those of Hankins and Howe (1946), which are:

(3) Ether extract in the edible [3] portion of the dressed carcass=3.49 +0.74 (ether extract in the edible [3] portion of the 9-10-11th rib cut).

(4) Protein in the edible [3] portion of the dressed carcass=6.19+ 0.65 (protein in the edible [3] portion of the 9-10-11th rib cut).

The resulting equations are as follows:

(5) Percent of fat in the boneless portion of steer carcasses=7.89+ 8.51 [weight of fat in the two side probes (in grams)] + 0.0183 [warm carcass weight (in pounds)].

(6) Percent of protein in the boneless portion of steer carcasses= 19.47—1.3 [weight of fat in the two side probes (in grams)] —0.0042 [warm carcass weight (in pounds)].

Summmary

A core sampling technique for estimating the fat and protein content of steer carcasses is described. The method is reasonably quick and easy to apply and causes very little damage to the carcass. The multiple correlation coefficients (R^2) between the weight of fat in two side probes and warm carcass weight with percentage of fat and percentage of protein in the 9-10-11th rib cuts were 0.781 and 0.735, respectively. These associations are of sufficient magnitude to make them useful in studying the composition of large numbers of steer carcasses.

Equations are derived for predicting the fat and protein content of the edible portion of the 9-10-11th rib cut. These equations have been combined with those of Hankins and Howe (1946) so that the equations thus derived predict the fat and protein content of the edible portion of steer carcasses.

Literature Cited

Aunan, W. J. and L. M. Winters. 1952. A method of measuring the proportion of fat and lean tissue in swine carcasses. J. Animal Sci. 11:319.

Hankins, O. G. and Paul E. Howe. 1946. Estimate of the composition of beef carcasses and cuts. U.S.D.A. Tech. Bull. 926.

Hankins, O. G. and H. W. Titus. 1939. Growth, fattening and meat production. In: U. S. Department of Agriculture Yearbook, p. 450.

Lawes, J. B. and J. H. Gilbert. 1858. Experimental inquiry into the composition of some of the animals fed and slaughtered for human feed. Phil. Trans. Royal Soc. 149:493.

Lush, J. L. 1926. Practical methods of estimating proportion of fat and bone in cattle slaughtered in commercial packing plants. J. Agr. Res. 32:727.

[3] Hankins and Howe (1946) "edible portion" is the boneless portion of a cut or carcass.

EFFECT OF MINERAL SUPPLEMENTATION ON PORK MUSCLE COLOR AS MEASURED BY SPECTROPHOTOMETRY AND DISK COLORIMETRY [1]

W. E. HENRY AND L. J. BRATZLER

Michigan Agricultural Experiment Station, Michigan State University, East Lansing

THE color of fresh lean meat has long been an important criterion to consumers in the selection of meat from the retail counter. Wilson *et al.* (1959) stated that the ideal color of fresh pork is greyish-pink. Larzelere *et al.* (1956), in a consumer preference study, found that 61.8% of the dark colored pork chops were selected over greyish-pink pork chops. Research has found that factors such as pH, age, breed, species, exercise, and the ration affect the myoglobin concentration in the muscle. Several chemical additives have been found to stabilize the color of cured pork; however, at the present time a suitable method for stabilizing the color of fresh meat is not known. Bray *et al.* (1959) found that the supplementation of copper and iron in veal calf rations had a significant effect on the color and myoglobin content present in the muscle. Studies have indicated that exercise increases myoglobin content (Kennedy *et al.*, 1926; Millikan, 1939; Shenk *et al.*, 1934; Hall *et al.*, 1944; Poel, 1949; Lawrie, 1950; Briskey, 1959). Mitchell (1933), in a study of the effect of exercise on the color of beef muscle, stated that no difference was observed between exercised and unexercised cattle. Bull *et al.* (1942) and Craig *et al.* (1958) support Mitchell's findings in that no difference in myoglobin concentrations was found between exercised and unexercised beef steers. Craig *et al.* (1958) stated that the differences in color of lean were due to varying amounts of fat and moisture rather than the difference in pigment concentration.

The present study was designed to examine the effects of mineral supplementation of swine rations upon the color and myoglobin content of pork muscle.

Materials and Methods

The hog carcasses in this study were obtained from an experiment at Michigan State University designed to determine the relationship of zinc, iron and copper supplementation to the incidence of parakeratosis in swine (Hoefer *et al.*, 1960). After the initial parakeratosis study, the animals were continued on the respective rations to approximately 200 lb., slaughtered, and physical and chemical determinations made. Extreme range in age at slaughter was from 180 days to 210 days.

[1] Journal Article 2633, Michigan Agricultural Experiment Station.

Two separate trials involving a total of 80 hogs were conducted. Trial I consisted of 35 purebred Hampshire hogs and Trial II consisted of 43 crossbred hogs. Two additional animals were used in the study of the relationship between myoglobin and surface color.

The basic ration was a typical fattening ration consisting of corn, soybean meal, meat and bone scraps, fish meal, alfalfa meal, limestone, dicalcium phosphate, iodized salt, B-vitamin mix, A and D concentrate, B_{12}, and chlortetracycline (Aurofac 10).

In both Trials I and II, the animals were divided at random into five lots, each lot receiving various combinations and levels of iron, zinc, and

TABLE 1. ZINC, COPPER AND IRON SUPPLEMENTATION AT CALCIUM LEVELS OF 1.05, 0.55 AND 1.31 PERCENT

Lot number	Number of animals	Level of calcium, %	Level of trace minerals in ration[a]
Trial I			
1	7	1.05	Zinc—50 ppm
2	5	1.05	Iron—100 ppm
3	7	1.05	Zinc—50 ppm and iron—100 ppm
4	7	1.05	Copper—125 ppm
5	8	1.05	Copper—125 ppm and zinc—50 ppm
Trial II			
1	10	0.55	———
2	10	0.55	Zinc—75 ppm
3	10	0.55	Copper—125 ppm
4	9	1.31	Copper—125 ppm
5	4	1.31	Zinc—75 ppm

[a] Trace minerals fed as zinc carbonate, copper sulfate and ferrous sulfate.

copper with varied levels of calcium (table 1). The animals were fed in dry lot, being allowed water and feed *ad libitum*.

The animals were slaughtered at a weight of approximately 200 lb. The carcasses were chilled at 36–40° F. for a period of 2 days after slaughter. After chilling, the 3rd to 10th rib section was removed from the right loin for fat, moisture, color, and myoglobin determinations. The *Longissimus dorsi* muscle was removed and trimmed of all external fat. Color measurements were made on a 2-cm. slice taken at the 10th rib section. The remaining portion of the *Longissimus dorsi* was ground five times through a 5/64-in. plate to assure homogeneity, and fat, moisture and myoglobin determined.

Munsell spinning disks were used to determine the surface color of the lean meat. A sample consisting of a 2-cm. slice of the *Longissimus dorsi*, taken at the 10th rib, was placed in a 36°–40° F. cooler and color measurements taken at the end of 2 hours. For evaluation of desirable

pork muscle color, a pork loin sample was selected by members of the Michigan State Animal Husbandry Department. The sample had a renotation of 4.3 yellow-red, 4.9 value and 3.6 chroma which was considered as an "ideal" pork color. This color was considered as the standard for calculating the index of fading by the formula of Nickerson (1946).

The quantitative determination of myoglobin as outlined by Ginger *et al.* (1954) was used in the study with the exception of slight modifications. Duplicate 25-gram aliquots of the ground samples were minced in a Waring Blender for two minutes with 100 ml. of cold distilled water. This was different from the procedure of Ginger *et al.* (1954) who used overnight extraction in a refrigerator by mixing 10 gm. of ground meat with 10 ml. of water. After blending, the solutions were centrifuged for 20 minutes at 2500 rpm. All centrifugation was carried out at temperatures of 34 to 38° F. Solid mono and dibasic potassium phosphate was added to precipitate the hemoglobin (Ginger *et al.*, 1954). To alleviate the difficulty encountered in dissolving the monobasic potassium phosphate it was first ground and sifted through a 250- micron sieve. In calculating the concentration of myoglobin per gram of fresh tissue, the extinction coefficient of 11.5, equivalent to that of cyanomethemoglobin (Drabkin and Austin, 1935–36) and a molecular weight of 16,500 for myoglobin (Ginger *et al.*, 1954) was assumed.

Procedures as prescribed by the AOAC were used to determine fat and moisture in order to study their relationship to myoglobin and to color.

Results and Discussion

Table 2 summarizes the results obtained in Trial I. Only the animals which reached 200 lb. from the initial parakeratosis experiment were used; thus, the reason for the varied numbers. Little variation existed between moisture, fat and myoglobin content between treatments. Greater variation in myoglobin content existed between animals than between treatments. The loin eye of animals receiving iron or iron plus zinc contained slightly more myoglobin (3.55 mg./gm.) than did those of animals receiving zinc, copper, or copper plus zinc (3.44 mg./gm.). The results of this experiment are not in agreement with Bray *et al.* (1959) who indicated that supplementation of iron and copper to veal calf rations increased myoglobin concentration. In their work, 240 mg. iron and 7 mg. of copper were fed daily per animal. In the present study, minerals were mixed into the ration prior to feeding and estimation of mineral intake per animal was based upon daily feed consumption. The average daily mineral intake for the five treatments was 107 mg. of zinc in treatment I, 105 mg. of iron in treatment II, 103 mg. of zinc plus 206 mg. of iron in treatment III, 280 mg. of copper in treatment IV, and 109 mg. of zinc plus 273 mg. of copper in treatment V. Thus, the level of iron fed in this study was approximately one-half the level (125 vs. 240 mg./gm. daily) fed by Bray *et al.* (1959).

TABLE 2. SUMMARY OF RESULTS OBTAINED WITH HAMPSHIRES IN TRIAL I (Ca LEVEL, 1.05%)

Treatment	I Zn	II Fe	III Zn+Fe	IV Cu	V Cu+Zn
No. of pigs	7	5	7	7	8
H_2O,[a] %	73.62	74.89	74.08	74.00	74.19
Fat,[a] %	3.20	2.72	2.68	2.37	2.53
Myoglobin[b] mg./gm.	0.815	0.796	0.826	0.816	0.760
Myoglobin[c] mg./gm.	3.52	3.55	3.55	3.44	3.27
Range of myoglobin mg./gm.	3.02–3.98	2.91–4.59	3.28–3.93	2.88–5.02	5.46–4.93
Munsell renotations	6.8 YR 5.5/2.8	6.4 YR 5.6/2.7	7.4 YR 5.7/2.9	6.8 YR 5.6/3.0	7.1 YR 5.5/2.9
Index of fading[d]	8.7	9.3	9.6	8.3	8.8

[a] Fresh basis.
[b] Myoglobin expressed in mg./gm. of fresh muscle tissue.
[c] Myoglobin expressed in mg./gm. on a moisture-free, fat-free basis.
[d] Standard=Hue 4.3 Yellow-Red, Value 4.9, Chroma 3.6.

TABLE 3. SUMMARY OF RESULTS OBTAINED WITH CROSSBREDS IN TRIAL II

	0.55 % Ca			1.31 % Ca	
Treatment	I Control	II Zn	III Cu	IV Cu	V Zn
No. of pigs	10	10	10	9	4
H_2O,[a] %	73.41	73.36	73.32	72.84	73.46
Fat,[a] %	4.45	4.65	4.19	4.52	4.10
Myoglobin[b] mg./gm.	0.785	0.844	0.851	0.805	0.828
Myoglobin[c] mg./gm.	3.52	3.84	3.76	3.56	3.69
Range of myoglobin mg./gm.	2.31–4.13	3.02–4.76	2.73–5.03	2.47–4.31	2.96–4.66
Munsell renotations	6.4 YR 5.7/2.9	5.8 YR 5.5/3.1	6.1 YR 5.4/3.1	6.8 YR 5.7/3.1	7.2 YR 5.7/2.8
Index of fading[d]	8.3	7.3	6.6	8.6	9.2

[a] Fresh basis.
[b] Myoglobin expressed in mg./gm. of fresh muscle tissue.
[c] Myoglobin expressed in mg./gm. on a moisture-free, fat-free basis.
[d] Standard=Hue 4.3 Yellow-Red, Value 4.9, Chroma 3.6.

Also, it may be noted that in the present study no copper was fed in combination with iron. It is conceivable that the results of the two studies would have been in closer agreement had similar levels of iron been fed, or had iron and copper been fed in combination as in the veal experiment. It is recognized that the physiological differences between the two groups of animals studied, such as species and growth rate, would also have to be taken into account in any close comparison. Market weight hogs (200 lb.) are nearer physiological maturity than veal calves that are dressed at about the same weight. Myoglobin concentration increases with age and maturity, therefore, at the degree of maturity of the hogs studied, the treatment difference in myoglobin content may have been minimized. In trial II (table 3) the average daily mineral intake was: 114 mg. of zinc, 295 mg. of copper, 104 mg. of zinc and 218 mg. of copper for treatments II, III, IV and V, respectively. As indicated in table 3, there is very little variation in moisture, fat or myoglobin concentration between treatments. These data (Trial II) are very similar to the data of Trial I in that copper or zinc had little effect on total myoglobin concentration. In addition, greater variation was observed between animals within treatments than between treatments. Both trial I and II were statistically analyzed by the analysis of variance as outlined by Snedecor (1957) and indicated no significant differences between treatments.

Although the Munsell spinning disks are rather sensitive objective measurements of color, they have certain disadvantages. Foremost of these are the rather lengthy time required to match a sample and the different concepts of color existing amongst operators. Since temperature and light are factors influencing the rate of change of myoglobin to metmyoglobin in fresh muscle tissue, it is essential that color measurements be made under refrigerated conditions and as rapidly as possible to obtain accurate results. In the present study, it was found that 2 or 3 minutes were required to make a color match. Exact matching of samples was not obtained in every instance. It was found in this study, and also by Voegeli (1952), that occasionally the addition of one unit of white would change the disk mixture from darker than the sample to lighter than the sample. In order to facilitate the use of whole units of disk area in calculating renotation values, it was decided to use the lighter readings for purposes of standardization.

By comparison of myoglobin, fat, and moisture content and index of fading of all samples studied, the following relationships were found: index of fading versus myoglobin content produced the highly significant correlation coefficient of —.69 (figure 1) which supports the concept of myoglobin being highly associated with muscle tissue color; although over one-half of the variability ($1-r^2$) between the two methods was unaccounted for, the predicting formula of $Y=1.01-.023$ (X) appears to be a useful estimator for predicting myoglobin content from disk color-

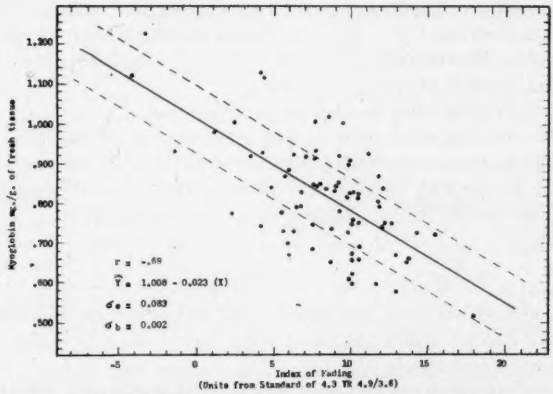

Figure 1. Correlation between index of fading and milligrams of myoglobin per gram of fresh tissue.

imetry readings of fresh pork loin muscle, when Y=myoglobin and X= index of fading.

By comparison of the fat content with index of fading and myoglobin concentration, the low and insignificant correlation coefficients of 0.21 and —.29, respectively, were obtained, indicating that little relationship exists between fat content and muscle color (table 4). Such appears to be true whether color is measured as a surface phenomenon by disk colorimetry or as total myoglobin content determined spectrophotometrically.

The effect of moisture content upon index of fading and myoglobin was found to be low and in a negative direction as indicated by the non-significant correlation coefficients of —.16 and —.13, respectively. The slight effect upon color due to variations in fat and moisture content appears to be somewhat of a lightening effect (increase in value) with an increase in fat, and a slight darkening of muscle color (decrease in value) with an increase in moisture. The usual high relationship between

TABLE 4. CORRELATION BETWEEN PHYSICAL AND CHEMICAL RELATIONSHIPS OF PORK *LONGISSIMUS DORSI*

Item	"r"
Fat vs. index of fading	0.21
Fat vs. myoglobin	—0.29
Moisture vs. index of fading	—0.16
Moisture vs. myoglobin	—0.13
Myoglobin vs. index of fading	—0.69**
Moisture vs. fat	—0.88**

** Significant (P=0.01).

fat and moisture content was found as indicated by the highly significant correlation coefficient of —.88. As shown by the similarity of index of fading values for the control lots in both trials, no color differences were found that could be attributed to breed.

These findings are not in accordance with Craig *et al.* (1958), who indicated that differences in color of lean meat were due to varying amounts of fat and moisture rather than differences in pigment concentration. The results of the present study would indicate that color differences cannot be explained on the basis of fat and moisture concentration.

Summary

The levels of zinc, iron and copper used to supplement swine rations in this study had no significant effect upon myoglobin concentration of the *Longissimus dorsi* muscle.

A highly significant relationship was found between the index of fading and myoglobin concentration. From this, it may be concluded that disk colorimetry might be used as a method for estimating myoglobin content of pork muscle.

The effect of fat and total moisture content upon color renotations and myoglobin concentrations was found to be non-significant. This indicated that little relationship exists between the fat and moisture content of pork muscle and its color, whether it be measured as a surface phenomenon by disk colorimetry, or as a pigment concentration by spectrophotometry.

Literature Cited

Bray, R. W., E. H. Rupnow, F. M. Manning, N. N. Allen and R. P. Niedermeier. 1959. Effect of feeding methods on veal production and carcass quality. II. Carcass grades, liver, hide, specific gravity, yield and chemical analysis of the muscle. J. Animal Sci. 18:732.

Briskey, E. J., R. W. Bray, W. G. Hoekstra, R. H. Grummer and P. H. Phillips. 1959. The effect of various levels of exercise in altering the chemical and physical characteristics of certain pork ham muscles. J. Animal Sci. 18:153.

Bull, Sleeter and H. P. Rusk. 1942. Effect of exercise on quality of beef. Ill. Agr. Exp. Stat. Bul. 488:107.

Craig, H. B., T. N. Blumer and E. R. Barrick. 1959. Effect of several combinations of grass and grain in the ration of beef steers on the color characteristics of lean and fat. J. Animal Sci. 18:241.

Drabkin, D. L. and J. H. Austin. 1935–36. Spectrophotometric studies, preparations from washed blood cells; nitric oxide hemoglobin sulfhemoglobin. J. Biochem. 112:51.

Ginger, I. D., G. D. Wilson and B. S. Schweigert. 1954. Biochemistry of myoglobin. Agr. and Food Chem. 20:1037.

Hall, J. L., E. E. Latscher and D. L. Mackintosh. 1944. Quality of beef. Kansas Agr. Exp. Stat. Tech. Bul. 58, Part IV.

Hoefer, J. A., E. R. Miller, D. E. Ullrey, H. D. Ritchie and R. W. Luecke. 1960. Interrelationship between calcium, zinc, iron and copper in swine feeding. J. Animal Sci. 19:249.

Kennedy, R. P. and G. H. Whipple. 1926. The identity of muscle hemoglobin and blood hemoglobin. Am. J. Physiol. 70:685.

Larzelere, H. E. and R. D. Gibb. 1956. Consumer's opinion of quality in pork chops. Michigan State Univ. Quarterly Bul. 30:327.

Lawrie, R. A. 1950. Some observations on factors affecting myoglobin concentrations in muscle. J. Agr. Sci. 40:356.

Millikan, G. A. 1939. Muscle hemoglobin. Physiol. Reviews 19:503.

Mitchell, H. H. and T. S. Hamilton. 1933. Effect of long-continued exercise upon the chemical composition of the muscle and other tissues of cattle. J. Agr. Res. 46:917.

Nickerson, Dorothy. 1948. Color measurement and its application to the grading of agricultural products. U.S.D.A. Publication 580.

Poel, W. E. 1949. Effect of anoxia on myoglobin concentrations in striated muscle. Am. J. Physiol. 156:44.

Shenk, J. H., J. L. Hall and H. H. King. 1934. Spectrophotometric characteristics of hemoglobin. I. Beef blood and muscle hemoglobin. J. Biol. Chem. 105:741.

Snedecor, G. W. 1957. Statistical Methods (5th ed.). The Iowa State College Press, Ames, Iowa.

Voegeli, M. M. 1952. The measurement of fresh beef muscle color changes by disk colorimetry. Ph.D. Thesis. Michigan State Univ.

Wilson, G. D., I. D. Ginger, B. S. Schweigert, W. J. Aunan. 1959. A study of the variation of myoglobin concentration in "two-toned" hams. J. Animal Sci. 18:1080.

CONTINUOUS VERSUS INTERMITTENT OBSERVATIONS IN BEHAVIOR STUDIES WITH GRAZING CATTLE

J. L. Hull, G. P. Lofgreen and J. H. Meyer [1]

University of California, Davis

MANY studies of behavior patterns of grazing animals (Duchworth and Shirlow, 1958; Smith, 1959) report on the importance of incorporating animal behavior studies with production data when solving pasture management problems. Tribe (1949) reported observations made over a 12-month period on the grazing habits of five sheep and assumed that data collected for various activities of only one animal reflected the actions of the five sheep. Hancock (1954) used 10 sets of monozygotic twin dairy cows to measure the degree to which grazing behavior depends on individuality and found that conclusions based on the observation of a few individual animals may not be generally valid; in fact, the outstanding feature of the grazing behavior was its variability due to internal and external conditions as applied to the animals. It was also found that observations from a greater number of animals reduced the variability and seemed to be necessary for a complete picture because of the great individual variation.

Taylor (1953) and Harker *et al.* (1954) used a 4-minute interval of observation for reporting behavior studies of grazing cattle and presented evidence of close agreement between the 4-minute interval and continuous interval of observation. They assumed that the numbers of animals observed in a given behavior group continued in that particular behavior until the time of the next observation. Shepard *et al.* (1957) reported grazing habits based on observations at 30-minute to 1-hour intervals. The calculations were based on percentages of all animals in a given behavior with the assumption also that the behavior at the time of observation was representative of the interval of time between observations. Lofgreen *et al.* (1957) used this same technique in reporting studies of grazing animals and animals fed soilage but used a 15-minute interval of observation over a 24-hour period. They also found excellent agreement in grazing behavior between that observed on any specific day of a rotation interval compared to the same day of the subsequent rotation interval.

In the studies of Shepard *et al.* (1957) no observations were made between 10 p.m. and 2 a.m., based upon the assumption that little activity occurs during those hours. Atheson *et al.* (1942) and Hughes and Reid (1951) discovered that grazing occurred during the night but the periods were not sharply defined. Fisher *et al.* (1954), for example, found that lactating dairy cows averaged 51% of their grazing time during the night.

[1] Department of Animal Husbandry.

It was the purpose of the research reported herein to study the frequency of observation needed to obtain a complete picture on animal behavior during a 24-hour grazing period.

Experimental

The observations reported in this study were made on animals being used in a study of the effect of recovery interval of irrigated forage on the performance of grazing steers (Hull *et al.*, 1960). The irrigated pasture grazed consisted of trefoil (*Lotus tenuis*) and orchardgrass (*Dactylis glomerata*).

One lot of four Hereford feeder steers receiving barley supplement while grazing irrigated forage in a field of approximately 0.40 acre was observed

TABLE 1. BEHAVIOR PATTERNS OF FOUR STEERS UNDER CONTINUOUS OBSERVATIONS

Animal number	Eating		Ruminating		Idling		Drinking
	Green forage	Supplement	Standing	Lying	Standing	Lying	
	Time spent, hours						
1	7.60	0.63	0.52	3.60	4.13	7.30	0.22
2	5.98	0.75	0.83	5.15	4.45	6.70	0.13
3	6.30	0.34	3.73	2.22	8.26	3.08	0.07
4	5.72	0.73	0.42	5.00	5.05	6.90	0.15
Mean	6.40	0.61	1.38	3.99	5.47	6.00	0.14

continuously for 24 hours, one observer per steer. A continuous record was made of the time the individual steer spent grazing, eating supplement, standing ruminating, standing idle, lying ruminating, lying idle, and drinking water. These data were compared to 15-, 30- and 60-minute observation intervals obtained from a check of the continuous observation data at the end of each 15-, 30- and 60-minute interval over the 24-hour period. The total time spent in a given behavior exclusive of the continuous observation was calculated on the assumption that the animal observed in a particular behavior pattern remained in that pattern until the next observation (Lofgreen *et al.*, 1957).

Results and Discussion

The behavior patterns of the four steers under continuous observation, presented in table 1, show that there was a wide variation in individual animal behavior patterns during a 24-hour period. When these data are compared to a spot-check of the same data at 15-, 30- and 60-minute intervals (table 2), it was found that individual animal behavior patterns varied greatly regardless of the time of observation. The major behavior patterns—grazing, ruminating or idling—were in excellent agreement if

TABLE 2. COMPARISON OF BEHAVIOR PATTERNS OF FOUR STEERS WHEN OBSERVED AT DIFFERENT TIME INTERVALS

Interval of observation	Eating		Ruminating		Idling		Drinking
	Green forage	Supplement	Standing	Lying	Standing	Lying	
	Time spent, hours						
Continuous	6.40±.36[a]	0.61±.08	1.38±.69	3.99±.59	5.47±.82	6.00±.85	0.14±.02
15 minutes	6.19±.42	0.50±.09	1.31±.64	4.19±.68	5.69±.64	6.00±.91	0.13±.04
30 minutes	6.25±.68	0.25±.12	1.25±.65	5.13±.83	5.87±.54	5.00±.73	0.25±.18
60 minutes	6.00±.92	0.00	1.00	4.75±1.02	6.75±1.34	5.50±.75	0.00

[a] Standard error of the mean.

the animals were observed at any time interval from continuous to 30 minutes, and no significant differences were obtained up to the 60-minute observation interval. The time spent eating supplement, however, was not reliably estimated with an interval greater than 30 minutes. Not enough data were available to obtain differences in time spent drinking water when expanded from the continuous observation. These data agree with those of Harker *et al.* (1954) showing differences in major and minor habits when observed at 4-minute intervals with the minor habits having a higher prediction error.

From the data in table 2, two general conclusions can be drawn: (1) up to a 30-minute interval between observations was adequate for reporting major animal behavior patterns, but more frequent observation was necessary for minor behavior patterns; (2) several animals need to be observed because of great individual variation. The use of a 15- or 30-minute time interval of observation not only allows one observer to record data from many animals but also reduces the number of observers needed, thus alleviating the criticism of most animal behavior studies.

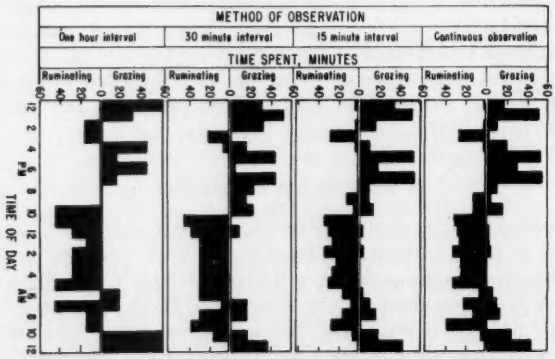

Figure 1. Animal behavior comparisons of method of observation.

Grazing time and ruminating time over the 24-hour period are compared with observation time in figure 1. These data show that it cannot be assumed that animals have little or no activity during the hours of darkness because grazing did occur at night. This also was the time of greatest rumination, agreeing with the observations by Taylor (1953).

Summary

Data are presented for grazing steers showing that, depending on criteria of interest, up to a 30-minute interval of observation was adequate for reporting animal behavior patterns. It was shown for the major behavior patterns—grazing, ruminating, and idling—that it can be assumed that the observed animal remains in a particular behavior pattern until the next observation, providing the observation interval was not over 30 minutes. Highly significant differences in individual animal behavior patterns over a 24-hour period were noted and therefore several animals need to be observed every 15 to 30 minutes. In this study four animals per treatment were adequate to obtain reliable estimates of animal behavior.

Literature Cited

Atheson, F. W., A. D. Shaw and H. W. Cave. 1942. Grazing habits of dairy cattle. J. Dairy Sci. 25:779.

Fisher, H. L., G. C. Graf, W. A. Hardison and N. R. Thompson. 1954. The grazing behavior of lactating cows on pasture. J. Dairy Sci. 37:665.

Duchworth, J. E. and D. W. Shirlow. 1958. The value of animal behavior records in pasture evaluation studies. J. Animal Behavior 6:139.

Hancock, John. 1954. Studies of grazing behavior in relation to grassland management. I. Variations in grazing habits of dairy cattle. J. Agr. Sci. 44:420.

Harker, K. W., J. I. Taylor and D. H. L. Rollinson. 1954. Studies on the habits of Zebu cattle. I. Preliminary observations on grazing habits. J. Agr. Sci. 44:193.

Hughes, G. P. and D. Reid. 1951. Studies on the behavior of cattle and sheep in relation to the utilization of grass. J. Agr. Sci. 41:350.

Hull, J. L., J. H. Meyer and G. P. Lofgreen. 1960. The effect of recovery interval of irrigated forage on the performance of grazing steers. J. Animal Sci. 19:981.

Lofgreen, G. P., J. H. Meyer and J. L. Hull. 1957. Behavior patterns of sheep and cattle being fed pasture or soilage. J. Animal Sci. 16:793.

Shepard, A. J., R. E. Blaser and C. M. Kincaid. 1957. The grazing habits of beef cattle on pasture. J. Animal Sci. 16:681.

Smith, C. A. 1959. Studies on the Northern Rhodesia Hyperrbenia Veld. I. The grazing behavior of indigenous cattle grazed at light and heavy stocking rates. J. Agr. Sci. 52:369.

Taylor, J. C. 1953. The grazing behavior of bullocks under two methods of management. J. Animal Behavior 1:72.

Tribe, D. F. 1949. Seasonal observations on grazing habits of sheep. Emp. J. Exp. Agr. 27:106.

EFFECT OF SOME CONTROLLABLE ERRORS ON ESTIMATES OF GENETIC PARAMETERS, WITH SPECIAL REFERENCE TO EARLY POST-NATAL GROWTH IN MERINO SHEEP

G. M. TALLIS [1, 2]

Glebe, N.S.W., Australia

IN animal-breeding work, it is not always possible either to make observations on animals at a standard time or age, or even to adjust the recorded measurements to a standard basis before estimating genetic parameters. As an example, consider the estimation of heritability of birth weight of lambs, and its genetic correlation with other characters. Facilities and labour may not be available for collecting and weighing lambs immediately after birth, and errors result, depending on the lapse of time between birth and weighing. Labour may be saved by inspecting the lambing flock at less frequent intervals, but in the process the expected error term is increased. It is the purpose of this paper to investigate the effect of such "controllable" errors on estimates of heritability and genetic correlation.

Methods

It will be assumed, firstly, that the genetic parameters are to be estimated from half-sib data. Later, the case of estimation from parent-offspring regression will also be considered.

The genetic model for character x of the jth offspring of the ith sire group (x_{ij}) may be written:

$$x_{ij}=\mu+\tfrac{1}{2}g_i+c_{ij}+f_{ij} \qquad (1)$$

where μ is the population mean, $\frac{1}{2}g_i$ is the gene contribution from the ith sire, c_{ij} is some controllable error term and f_{ij} is the random error. It is assumed that the terms of equation (1) are independent. The relevant analysis of variance and covariance model for the qth and rth traits is given in table 1. It is appropriate to point out here that situations arise in

TABLE 1. ANALYSIS OF VARIANCE OR COVARIANCE

Source	d.f.	M.S. or Cov [a]	E(M.S.) or E(Cov)
Between sires	d_s	V_{qr}	$C_{qr}+F_{qr}+\frac{k}{4}G_{qr}$
Within sires	d_l	v_{qr}	$C_{qr}+F_{qr}$

[a] For mean square q=r.

[1] Division of Animal Genetics, C.S.I.R.O., McMaster Laboratory.

[2] Some data used in the example were obtained from records of experimental sheep maintained at the National Field Station, "Gilruth Plains", Cunnamulla, N.S.W.

practice where the components of (1) cannot be considered as statistically independent and, in these cases, the following analyses are inadequate.

It can be shown that $F_{qr}=\frac{3}{4}G_{qr}+E_{qr}$, where E_{qr} is an environmental variance or covariance, and hence G_{qr} can be estimated without bias in the usual way by

$$\hat{G}_{qr}=(4/k)\,[V_{qr}-v_{qr}] \tag{2}$$

As, by definition, the genetic correlation between x_q and x_r is estimated by

$$\hat{r}_g=\frac{\hat{G}_{qr}}{(\hat{G}_{qq}\cdot\hat{G}_{rr})^{1/2}} \tag{3}$$

it may be seen that the controllable error terms in no way bias $\hat{r}_g$.

On the other hand, the heritability of x_q is defined to be

$$h^2_q=\frac{G_{qq}}{G_{qq}+E_{qq}} \tag{4}$$

and, because v_{qq} is usually used as an estimate of $F_{qq}=\frac{3}{4}G_{qq}+E_{qq}$, h^2_q is estimated by

$$\hat{h}^2_q=\frac{4(V_{qq}-v_{qq})}{V_{qq}+(k-1)v_{qq}} \tag{5}$$

Hence, in this case, if $C_{qq}>0$, h^2_q is biased downwards and the average amount of bias is

$$\frac{G_{qq}+E_{qq}}{G_{qq}+E_{qq}+C_{qq}}.$$

In the case of the parent-offspring method of estimating genetic parameters, similar results may be derived. For any character, the following models may be written

$$\begin{aligned} w_i&=\mu_w+g_i+c_i+e_i \\ x_{ij}&=\mu_x+\tfrac{1}{2}g_i+d_{ij}+f_{ij} \end{aligned} \tag{6}$$

where w and x represent parent and offspring phenotypes respectively, μ_w and μ_x are parent and offspring population means, g_i is the genetic deviation of ith parent from the mean parental genotype, c_i and d_{ij} are controllable error terms and e_i and f_{ij} are random errors. It is assumed that all components of the model are independent and that g_i, e_i and f_{ij} have zero expectations.

From (6) it may be shown that

$$E[w_{qi}-E(w_{q.})]\;[x_{rij}-E(\bar{x}_{ri.})]=\tfrac{1}{2}G_{qr}$$

where w_q and x_r represent parent phenotype for the qth character and offspring phenotype for the rth character respectively. Again, the G_{qr} can be estimated unbiasedly. The conventional formulae for $\hat{r}_g$ in this case are

$$\hat{r}_g=\frac{\hat{G}_{qr}+\hat{G}_{rq}}{2(\hat{G}_{qq}\cdot\hat{G}_{rr})^{1/2}} \quad\text{or}\quad \hat{r}_g=\left[\frac{\hat{G}_{qr}\cdot\hat{G}_{rq}}{\hat{G}_{qq}\cdot\hat{G}_{rr}}\right]^{1/2} \tag{7}$$

where $\hat{G}_{qr}$ and $\hat{G}_{rq}$ stand for 2 Cov $(\hat{w_q}x_r)$ and 2 Cov $(\hat{w_r}x_q)$ respectively. Because $\hat{r}_g$ is a function of the $\hat{G}_{qr}$, it is in no way biased by the controllable error terms.

Heritability is usually estimated from the formula

$$\hat{h}^2_q = \frac{2 \text{ Cov } (\hat{w_q}x_q)}{\text{Var } (\hat{w_q})} \tag{8}$$

since Var $(\hat{w_q})$ is taken as an estimate of $G_{qq}+E_{qq}$. This, of course, is only true when $C_{qq}=0$, and for $C_{qq}>0$ a biased estimate of h^2_q is obtained. The amount of bias is again

$$\frac{G_{qq}+E_{qq}}{G_{qq}+E_{qq}+C_{qq}}$$

However, it is worth stressing that C_{qq} is the controllable error variance component in the parent's data.

Formulae for computing the sampling variance of $\hat{r}_g$, Var $(\hat{r}_g)$, estimated from half-sib data have been presented (Tallis, 1959), and similar formulae for parent-offspring data are also available (Reeve, 1955). From a close investigation of these formulae it is clear that, in both types of data, controllable error terms tend to inflate Var $(\hat{r}_g)$. This is due, primarily, to the negative bias incurred by heritability estimates as a result of large C values. Thus, if two systems of data collection are to be compared and the second system (2) involves greater controllable error terms than the first (1), then, provided sufficient data are available Var $(\hat{r}_g)_1$ and Var $(\hat{r}_g)_2$ can be computed and compared. Moreover, if we let

$$\frac{\text{Var } (\hat{r}_g)_2}{\text{Var } (\hat{r}_g)_1} = R > 1$$

and s is the number of parent groups (sire groups or parent-offspring pairs), then if (2) is to provide as much information as (1), $s_2 = Rs_1$ parent groups will be necessary. The loss of efficiency as a result of using (2) instead of (1) is therefore $\frac{R-1}{R}$. This loss of efficiency, together with other factors, could help decide which system of data collection to adopt.

It is concluded from the above analyses that controllable error terms generally:

(i) tend to bias heritability estimates downwards.
(ii) do not bias estimates of genetic correlation.
(iii) increase the errors of estimate of genetic correlations.

Example. In order to illustrate the above results, the two characters birth weight (x_1) and weaning weight (x_2) of Merino sheep will be examined. However, before progress can be made, good estimates of the

genetic variances of x_1 (G_{11}) and x_2 (G_{22}) and the genetic covariance between them (G_{12}) are necessary. These estimates have been obtained from data on the experimental flock of medium Peppin Merino sheep maintained at the C.S.I.R.O. National Field Station, "Gilruth Plains", Cunnamulla. This flock has been described by Turner (1958). The data used were drawn from observations made on lambs and weaners in three mating groups and born during the three years 1954 to 1956. Genetic variance and covariance components were calculated in the conventional way from analyses of variance and covariance tables which had been computed on a within year, mating group and sex basis. These estimates, obtained with 82 degrees of freedom between-sires, and 1282 within-sires, were:

$$\hat{G}_{11}=0.1963 \quad \hat{G}_{22}=3.4526 \quad \hat{G}_{12}=0.2919$$

TABLE 2. VARIANCES OF ESTIMATES OF BIRTH WEIGHT [a] OBTAINED BY FOUR DIFFERENT METHODS

Group	Degrees of freedom	Variance between lambs
Lambs weighed immediately after birth	34	0.5820
Lambs collected once every 24 hours	39	0.6657
Lambs collected once every 48 hours	76	1.1934
Lambs collected once every 72 hours	108	1.3513

[a] Pounds.

So that heritability estimates could be calculated based on different procedures of data collection, phenotypic variances for birth weight were estimated during the 1958 lambing at the C.S.I.R.O. field station at Armidale, N.S.W. Four systems of data collection were considered:

a. The weighing of lambs at birth.
b. The weighing of all lambs born during a 24 hour period. Weighings were made daily at 8 a.m.
c. The weighing of all lambs born during a 48 hour period. Weighings were made every alternate day at 8 a.m.
d. The weighing of all lambs born during a 72 hour period. Weighings were made every three days at 8 a.m.

Clearly, the longer the interval between each set of weighings, the larger is the expected phenotypic variance because of the effect of the regression of weight on age. This fact is illustrated by the figures in table 2. From $\hat{G}_{11}$ and the phenotypic variances of table 2, it is possible to obtain a rough idea of the effect on heritability if the estimates of birth weights of lambs are not obtained immediately after birth. For instance, the estimate of heritability under system b of data collection is $\frac{0.1963}{0.6657}=0.295$ and the "bias factor" is calculated as $\frac{0.295}{0.337}=0.875$. In this manner, table 3 has been constructed.

The approximations in table 3 give some idea of the actual magnitude of the bias that can obviously be expected under the four systems of data collection. From these results it seems that undesirably large biases may be incurred if lambs are weighed at intervals longer than 24 hours.

Since system (b) of obtaining birth weights is used at "Gilruth Plains", it was possible to obtain data on weaning weights for a similar analysis. It was found that, if weaning weights are not corrected for age differences at weaning (system f), the estimate of the phenotypic variance is 44.2218. However, this estimate is reduced to 39.1376 after correction for age

TABLE 3. ESTIMATES OF HERITABILITY OF x_1, x_2 and x_2-x_1 UNDER DIFFERENT SYSTEMS OF DATA COLLECTION AND CORRECTION

Character	Type of collection or correction	Heritability	Bias factor
Birth weight (x_1)	a (at birth)	0.337	1.000[a]
	b (every 24 hours)	0.295	0.875
	c (every 48 hours)	0.164	0.487
	d (every 72 hours)	0.145	0.430
Weaning weight (x_2)	corrected for age (e)	0.088	1.000
	uncorrected for age (f)	0.078	0.886
x_2-x_1	a, e	0.091	1.000
	d, f	0.078	0.857

[a] 1.000=no bias.

(system e) is made. Estimates of the heritability of weaning weight under these two systems of data correction are also given in table 3. Thus, although the non-correction of the data for age tends to bias heritability of weaning weight downwards, the bias is not large.

Consider now the heritability (h^2_D) of gains from birth to weaning (x_2-x_1). Estimates of this parameter may be obtained from the expression

$$\hat{h}^2_D=\frac{\hat{G}_{11}+\hat{G}_{22}-2\hat{G}_{12}}{\hat{P}_{11}+\hat{P}_{22}-2\hat{P}_{12}}$$

Since controllable error terms are not expected to be correlated, P_{12} may be estimated and used here for all systems of data collection and correction. An estimate of P_{12} from the Gilruth Plains data is 3.0626, and, with this result, the estimates of h^2_D under systems a and e, and d and f have been calculated and recorded in the last two lines of table 3. Again, a relatively small bias is evident.

Now the genetic correlation between x_1 and x_2 is estimated from equation (3) to be 0.355. Under the two conditions of data collection described for h^2_D, the estimate of r_g is not affected by Var $(\hat{r}_g)_1$ and Var $(\hat{r}_g)_2$ were computed to be

$$\text{Var}\,(\hat{r}_g)_1 = 0.05136$$

$$R = \frac{0.09655}{0.05136} = 1.880$$

$$\text{Var}\,(\hat{r}_g)_2 = 0.09655$$

(The variances of $\hat{r}_g$ have been computed from the formulae developed by Tallis (1959)).

From these figures we can conclude that weighing lambs at three day intervals and not correcting weaning weights for age would result in a loss of efficiency (as defined in Section II) of $\frac{R-1}{R} = 0.47$. Therefore, if the second system of data collection and correction is to yield as much information as the first system, approximately $Rs_1 = 1.880 \times 82 = 154$ sires must be used. This result is rather surprising and re-emphasizes the importance of examining experimental procedures.

Discussion

The above example emphasizes that the effect of controllable errors on the estimation of genetic parameters can be large or small and, therefore, their importance depends on what the investigator's interests are. If, for instance, he wishes to select for birth weight, either to make genetic gains in birth weight or weaning weight, it is clear from the equations

$$\triangle g_1 = i\frac{G_{11}}{(P_{11})^{\frac{1}{2}}}, \qquad \triangle g_2 = i\frac{G_{12}}{(P_{11})^{\frac{1}{2}}}$$

that by inflating P_{11} by means of controllable error terms, drastically reduced expected genetic gains are obtained. Here $\triangle g_1$ and $\triangle g_2$ are the genetic gains in birth weight and weaning weight respectively and i is the selection differential in standard units.

Moreover, genetic correlations of birth weight with some other characters are estimated very inefficiently when errors involved in the measurement of birth weight are large. On the other hand, if the investigator is only interested in selecting for weight gain from birth to weaning, the type of data collection and correction have little influence on heritability and, hence, on genetic gains.

Another point which is re-emphasized is the necessity, when making predictions of genetic progress, for using estimates of heritability made in the same context. In the present example, the higher estimates of heritability obtained when weighing at birth would not be applicable if lambs were weighed only every three days.

Therefore, it is clear that the design of any equipment, which aims at selection of animals or the estimation of genetic parameters, depends entirely on the characters of interest. Obviously, forethought with the aid of some preliminary investigations may increase the efficiency of the experiment considerably.

Summary

In this paper the effect of some controllable errors on the estimation of heritability and genetic correlation is investigated. It is concluded that, although these controllable errors generally do not bias estimates of genetic correlation, heritability estimates may sustain a severe negative bias. Controllable errors also tend to inflate the sampling variances of estimates of genetic correlation. These findings are illustrated numerically for the two characters birth weight and weaning weight in Merino sheep.

Literature Cited

Reeve, E. C. R. 1955. The variance of the genetic correlation coefficient. Biometrics 11:357.

Tallis, G. M. 1959. Sampling errors of genetic correlation coefficients calculated from analyses of variance and covariance. Australian J. Stat. 1:35.

Turner, Helen Newton. 1958. Relationships among clean wool weight and its components. Australian J. Agr. Res. 9:521.

ERRATUM

J. Animal Sci. 19:919. In figure 2 curves from top to bottom should be labeled R=2, R=4, R=6 and R=20, respectively.

ABSTRACTS OF PAPERS FOR PRESENTATION AT THE 52ND ANNUAL NATIONAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meeting will be held November 25 and 26 in the Hotel Sherman, Chicago. The abstracts include program papers for the research sections and papers to be "read by title". Where a number only is shown, the abstract either was not submitted or was withdrawn, or it failed to qualify for publication.

1. INFLUENCE OF SUNLIGHT ON CANCER EYE IN CATTLE. David E. Anderson and Philip E. Skinner, *The University of Texas M.D. Anderson Hospital & Tumor Institute, Houston.*

The literature on cancer eye reads to the effect that the disease is more prevalent in the Southwest and West than elsewhere in the United States. The prevalence is usually attributed to high isolation, though direct support for this has never been offered. A survey of 45 herds in 23 states was made to provide information on this relation, and genetical information on susceptibility. In nine of these herds, disposal records were available showing which animals had been culled because of cancer eye. It is only this disposal material, as it relates to the question of sunlight and cancer, which forms the basis of the present report. Disposal records complete enough for analysis were available on 4,960 female Herefords which ranged in age from 2½ to 18 years. Differences in sunlight as measured by average annual hours of sunshine, latitude and altitude had significant effects on the incidence of cancer eye. The age-adjusted incidence increased significantly with an increase in annual hours of sunshine, a decrease in average latitude, and an increase in altitude. The average age at disposal was slightly lower in the areas characterized by high levels of sunlight. Other evidence of an association between sunlight and cancer eye has come from studies showing that eyelid pigment affords protection against the development of lid lesions, and from studies of the type of tumor observed in eye cancer.

2. EFFECT OF ENVIRONMENT DURING EARLY LIFE ON LIFETIME LAMB AND WOOL PRODUCTION OF EWES. G. E. Bradford, W. C. Weir and D. T. Torell, *University of California, Davis.*

One hundred, 6-month-old ewe lambs, 70 grade Corriedales and 30 Rambouillet-Merino crossbreds, were allotted to the experiment in July 1951. Fifty ewes, representing one-half of each breed group, were pastured until the following spring on unsupplemented range, while the remaining 50 were fed on irrigated clover pasture until late fall and then fed alfalfa hay plus 0.5 lb. barley per head per day during the winter. Beginning in April 1952 and continuing for 5 years, all ewes were managed as one flock under range conditions. No culling was practiced although some deaths occurred. Body weight, fleece weight and grade, and number and weight of lambs produced were recorded each year. Body masurements were taken at one and two years of age. Range-reared ewes were 25% lighter at 15 months and remained significantly lighter until past 4.5 years of age; produced significantly less wool at one and three years of age and slightly less in all years; but, consistently weaned a greater total weight of lamb per ewe, although this difference was not significant. The difference in lamb production was due to the larger number of lambs raised by range-reared ewes, in-

dividual lamb weights being the same for both treatments. Results indicate that ewes kept on a plane of nutrition which only slightly more than maintained body weight from six to fifteen months of age, though smaller than ewes more adequately fed, were fully equal to the latter in lamb-producing ability under range conditions.

3. INFLUENCE OF EARLY WEANING ON CREEP-FED MILK LAMBS WHEN WEANED ON WEIGHT OR AGE. Don G. Brothers and J. V. Whiteman, *Oklahoma State University, Stillwater, and Agricultural Research Service U.S.D.A.*

Early weaning of lambs may aid selection effectiveness for some traits by reducing the maternally caused variation in traits selected for at an early period in the lamb's life. However, the age or weight at weaning that does not adversely affect subsequent performance should be established before this is practiced. Two trials were conducted at the Ft. Reno Experiment Station. In the 1958–59 season one half of 121 lambs were weaned when they reached a minimum weight of 50 lb., and in the 1959–60 season one half of 104 lambs were weaned when they reached a minimum age of 56 days. All lambs and their dams were on wheat pasture, and the lambs were creep fed. In 1958–59 the average weight at weaning was 54 lb. and the average weaning age was 76 days. The weaned lambs made an average daily gain from weaning to market weight (90 lb.) of 0.52; lambs not weaned gained 0.54 lb./day. This difference was not significant. In 1959–60 the average weight at weaning was 46 lb. and the average weaning age was 62 days. The weaned lambs gained 0.47 lb./day and lambs not weaned, 0.52. This difference was apparently real ($P<.005$). In both years it appeared that weaning had its greatest influence on growth during the first two weeks after weaning. Average estimated live grades of lambs at marketing was not influenced by weaning in either year. This study indicates that lambs on wheat pasture and creep feed may be weaned when they reach both minimum weight and age of 50 lb. and 70 days, respectively, without influencing their subsequent gain or market grade.

4. THE INFLUENCE OF COLLECTION FREQUENCY ON SPERM NUMBER IN THE BOAR FOLLOWING X-IRRADIATION. D. F. Cox and R. L. Willham, *Iowa State University, Ames.*

Twenty-eight boars from the Duroc and Hampshire breeds were subjected to acute testicular X-irradiation in doses ranging from 300 to 900 roentgens slightly after puberty. Semen collections were made at approximately two-day, weekly, and bi-weekly intervals following exposure in 4, 9 and 15 of the boars, respectively. The total number of sperm in the ejaculate was determined from the concentration and strained volume of the semen. The average number of days after exposure to reach the lowest sperm count was 47, 59 and 70 in the groups collected every two days, weekly and bi-weekly, respectively. An initial recovery to approximately 2 billion sperm following the lowest count was made by 70, 71 and 73 days after exposure in the groups collected every two days, weekly and bi-weekly. The pattern of decline and initial recovery was not greatly influenced by dose except that at the higher doses the minimum sperm number was smaller. Some recovery following the minimum counts was seen in all boars although at high doses it was not large. The average level of sperm production over a period of a year following exposure was, however, largely dependent on dose. More frequent collection reduced the time from exposure to minimum count but was relatively ineffective in altering the time for a substantial number of the sperm produced after irradiation to appear in the ejaculate. Stored sperm could apparently be eliminated but the transport of new sperm was not readily altered by more frequent collection.

5. HERITABILITY OF VITAMIN A AND CAROTENOID CONCENTRATIONS IN BOVINE LIVER AND PLASMA. R. H. Diven, O. F. Pahnish, C. B. Roubicek, E. S. Erwin and H. M. Page, *The University of Arizona, Tucson.*

Heritability estimates for liver and blood plasma vitamin A and carotenoid concentrations were computed by the paternal half-sib method from data on the purebred Hereford progeny of 13 sires. These range-raised progeny were produced in 2 successive years without vitamin A or carotene supplementation. Blood samples and liver samples obtained by biopsy were collected at a mean weaning age of about 230 days (period I) and again at a mean age of about 350 days (period II). Blood samples for period I were limited to the second calf crop. Liver concentrations were measured in γ per gram of liver and plasma concentration were measured in γ per 100 ml. of plasma. Heritability estimates were computed within sex of progeny. Variance components attributable to sires within years were used to estimate genetic variances. Heritability estimates (period I) from data representing bull and heifer progeny, respectively, with 95% confidence intervals, were: liver vitamin A, 0.44 $\pm$ 0.49 and 0.72 $\pm$ 0.62; liver carotenoid, zero and 0.35 $\pm$ 0.52; plasma vitamin A, zero and 0.25 $\pm$ 0.60; plasma carotenoid, 0.13 $\pm$ 0.46 and 0.28 $\pm$ 1.24. Estimates for period II from data representing bull and heifer progeny, respectively, were: liver vitamin A, 0.20 $\pm$ 0.48 and 0.21 $\pm$ 0.53; liver carotenoid, 0.14 $\pm$ 0.45 and 1.32 $\pm$ 0.82; plasma vitamin A, zero and 0.06 $\pm$ 0.39; plasma carotenoid, 0.52 $\pm$ 0.57 and 0.26 $\pm$ 4.27.

6. CATALASE CONTENT OF RABBIT, RAM AND BULL SEMEN. R. H. Foote, V. T. Voigt and Nina Schales, *Cornell University, Ithaca, New York.*

Catalase content of semen was compared with crystallized lyophilized catalase, prepared commercially, containing 100 units of catalase per mg. Four ejaculates of semen from each of nine rabbits averaged 23 units of catalase per ml. of semen. The nine rabbits included four pairs of littermates, and litter differences were highly significant statistically, $P<0.01$. Four additional pairs of littermates were obtained; and, eight semen collections from each buck over a two-week period averaged 29 units of catalase per ml. of semen. Again litter differences were highly significant statistically, $P<0.01$. Both studies, though small, suggest a hereditary basis for differences in catalase content of rabbit semen. Catalase concentration in whole semen was not correlated with sperm concentration, and most of the catalase in centrifuged semen samples was found in the supernatant fluid. Sixty-six samples of ram semen averaged 1.1 units of catalase per ml. of semen. This was correlated with sperm concentration, $r=0.71$, $P<0.01$. Upon centrifugation of the semen most of the catalase was found in the sperm fraction. Thus, rabbits and rams differ not only in level of catalase, but in the fraction of semen containing most of the catalase. Thirty-six samples of bull semen from five dairy breeds and five samples of beef semen averaged 0.3 and 0.2 units of catalase per ml. respectively. Thus, bull semen appears to contain negligible quantities of catalase. The addition of catalase to extended bull semen markedly prolonged sperm survival, although the added catalase was recovered largely in the supernatant fluid of centrifuged semen.

7. GROWTH PATTERNS IN FOUR BREED-TYPES OF WETHER LAMBS. W. C. Foote, Darrell H. Matthews and Arlin D. Knight, *Utah State University, Logan.*

Body measurements were obtained at birth and weaning (150 days average) on 108 wether lambs of four different breed-types (Rambouillet, Columbia, Hampshire-whiteface cross, and Suffolk-whiteface cross). Weaning measurement/birth measurement

ratios (denominator=1.0) were 1.439, 1.606, and 2.257 for metatarsus length, head circumference, and hip width, respectively. These differed significantly indicating an order of growth. Breed-type differences were not significant but ratio x breed-type interactions were significant. Head circumference/hip width, metatarsus length/hip width and head circumference/metatarsus length ratios at birth and weaning allowed comparison of proportional growth of these skeletal parts at these two ages. Significant differences were found for age in all comparisons (3.993 vs. 2.842; 2.219 vs. 1.418; 1.802 vs. 2.008 for birth and weaning of the above ratios, respectively). Among breed-types, Rambouillet and Hampshire-cross lambs had a significantly wider head circumference/hip width ratio than the Columbia and Suffolk-cross (3.542 and 3.468 vs. 3.309 and 3.352, respectively). Rambouillet had a significantly wider metatarsus length/hip width ratio (1.912) than the Hampshire-cross (1.781) Suffolk-cross (1.790) and Columbia (1.791) and the Hampshire-cross a significantly wider head circumference/metâtarsus length ratio (1.969) than the Columbia (1.869), Rambouillet (1.873) and Suffolk-cross (1.910). Significant breed-type x age interactions were found for the head circumference/metatarsus length ratio. The ratio x breed interaction is partially explained by the breed-type differences shown in these ratios. These data indicate that while an order of growth probably occurs among skeletal parts, genotype imposes a modifying influence.

8. WOOL AND LAMB PRODUCTION OF SELECTED AND UNSELECTED EWES. John A. Gorman and L. S. Parker.

All ewe lambs at the Archer Field Station were saved and kept for 3 years. The lambs were divided into two groups, those that would normally be selected for replacement ewes and those that would normally be sent to market as surplus lambs. Two methods of selection were used. One group was selected by the usual visual-selection method and the other by a selection index. The two methods have shown no difference in effectiveness. The selected lambs have shown a lower mortality than the unselected group. Likewise they have shown more uniformly in type. The slight difference in wool production between the two groups has decreased as the ewes grew older. Likewise the weight differences have largely vanished. The pounds of lamb produced by the two groups has been similar. The record cards make more nearly accurate the selection of the ewes to cull from the flock.

9. ENVIRONMENTAL AND GENETIC FACTORS WHICH CONTRIBUTE TO THE WEANING WEIGHTS OF CREEP-FED ANGUS CALVES. H. K. Hamann, S. Wearden and W. H. Smith, *Kansas State University, Manhattan.*

The study was made on records of 1,861 weaning weights from creep-fed calves of the commercial Aberdeen Angus herd of the Ramsey Ranch in southeast Kansas over a 3-year period. The study was based on the linear model, weaning weight = overall average + age of dam + sex of calf + year + regression of weaning weight on age of calf + error, where age of dam varied from two to eight years and older, sex of calf was steer and heifer, and years 1957, 1958, and 1959. With the use of the least squares procedure, constants were fitted to the non-orthogonal data and the effects of each factor were obtained. The results were —64, —22, —1, 4, 23, 27, 32 for the two through eight years and older dams, respectively; 20, —20 for the steer and heifer calves, respectively (these calves having an average weaning age of 238 days); —9, 6, 3, for 1957, 1958, 1959, respectively, and a regression coefficient of weaning weight on age of calf of 1.4. Paternal half-sib and maternal half-sib correlations were used to estimate heritability which was 0.57.

10. SUBJECTIVE EVALUATION OF CUTTING YIELDS AND LOIN EYE AREA IN HOGS AND THEIR CARCASSES. G. Harrington, A. M. Pearson and W. T. Magee, *Cambridge University, England, and Michigan State University, East Lansing.*

Judges of breeding stock need to be more precise in their evaluation of economically desirable features of hogs than do buyers of market animals. The latter are concerned with large lots, and no lasting damage may be done if an error is made. The judge of breeding stock is concerned with individual animals and errors of judgement could seriously retard the progress of selection. The purpose of this investigation was to study the ability of experienced judges in consistently and correctly differentiating between live hogs and carcasses for economically important characteristics. Six batches of seven hogs each were examined at weekly intervals. The seven hogs within a batch were shown to the panel of judges in all possible combinations, making a total of 21 paired comparisons. The judge was asked to indicate which hog of each pair he considered the better for fatness, loin eye area, yields of certain untrimmed cuts and the yield of trimmed lean cuts. A similar procedure was adopted with the carcasses using a completely different panel of judges. Assessments of relative lean cut yield were more consistently made than those of relative loin eye area or percentage yield of rough loin. Although the judges for live hogs were somewhat more repeatable than the carcass judges, the carcass judges tended to be more accurate in relative ranking. Rank correlations suggested, however, that the experienced judges could rank the hogs or carcasses within a batch for percentage lean cuts no more accurately than could have been achieved using backfat thickness as the index.

11. HERITABILITIES OF MILK LAMB GAINS FROM BIRTH TO 50 POUNDS, 50 TO 90 POUNDS AND BIRTH TO 90 POUNDS. R. B. Harrington, Don G. Brothers and J. V. Whiteman, *Oklahoma State University, Stillwater, and Agricultural Research Service, U.S.D.A.*

Factors influencing lamb gains vary in relative importance during different growth periods. Measurement of inherited gaining ability should be most effective during those periods when the other variables exhibit less influence. Data were collected on 671 crossbred milk lambs out of grade Rambouillet and grade Rambouillet-Panama x Rambouillet ewes and sired by purebred Dorset rams. The data were collected over a 4-year period during which a total of 31 sire progeny groups were represented. Least squares analyses were used to estimate the variance components due to breed of dam, type of birth and rearing, sex and sires. The data were analyzed twice, once with the individual lamb's birth weight as a covariable and again with birth weight disregarded. When birth weight was considered as a covariable the average heritabilities of the 4-year period were about 0.10, 0.38 and 0.38 for average daily gain from birth to 50 lb., 50 to 90 lb. and birth to 90 lb., respectively. When differences due to birth weight were disregarded the corresponding heritabilities were about 0.11, 0.38, and 0.36, respectively. Thus, it would appear that early lamb gains are largely influenced by the dam's milk supply; whereas later gains are a better measure of the lamb's inherited ability to gain, and long term gains reflect a combination of these two sources of variation.

12. TEACHING SELECTION PRINCIPLES WITH HERD RECORDS GENERATED BY AN ELECTRONIC COMPUTER. T. Heidhues and C. R. Henderson, *Cornell University, Ithaca, New York.*

A one-semester course in advanced animal breeding encounters two major difficulties. Time and facilities do not permit selection experiments for quantitative traits in farm animals. A limited statistical background makes it difficult for the student

to visualize the practical applications of the theoretical concepts presented in this course. Therefore, it was decided to use the computing facilities of the Dairy Records Processing Laboratory to simulate a dairy herd for each student such that decisions concerning culling, mating and replacements could be made. This technique was first used by McGilliard at Michigan State University. The breeding goal was postulated to be an increase in milk production. An initial population was generated with parameters built-in which were based on estimates from New York data. Effects due to breeding value, permanent and temporary environment, genetic herd differences and permanent and temporary herd environments entered into each record. One week represented a year. During this time decisions had to be made concerning matings, culling of animals, and selection of herd replacements. Sires were selected from a common bull stud. Based on these decisions records and progeny for the next year were generated, taking into account sex ratio and mortality. Thus more information became available during the course, and the students had to meet the problems of an efficient record keeping system and the best possible use of these records. All students were able to improve their herds genetically. The amount of progress depended on the genetic herd level at the start of the experiment and the accuracy of the decisions about the animals during the course.

13. RELATION OF COMPLEMENTARY MILK TO PRODUCTION. Tapeshwar S. Kashyap, R. E. Comstock, J. D. Donker and W. E. Petersen, *Kimber Farms Inc., California, and University of Minnesota, St. Paul.*

An attempt was made (1) to determine how well the inherent capacity of an animal to produce milk can be estimated from percent complementary milk and other variables related to production and (2) to estimate the heritability of percent complementary milk. An analysis of Minnesota data (55 cows representing six breeds) showed that five observations of complementary milk would provide a satisfactory mean value for the whole lactation. Multiple regression and covariance analysis techniques were used to obtain prediction equations based on number of days to maximum production, age at calving, butter fat test nearest to maximum production, number of days a cow carries a calf during the lactation and percent complementary milk. The results indicated that percent complementary milk and maximum production were the only variables which made significant contribution to the prediction equation. Maximum production was defined as the average daily production for the 10-day period in which most milk was produced. Complementary milk is the amount of extra milk which is not available by regular machine milking, nursing or hand stripping but which is made available by injecting oxytocin. A final analysis included data from Minnesota and Georgia (38 Holsteins and 24 Jerseys). A multiple correlation (R^2) of total production with percent complementary milk and maximum production, of 0.659 was found in the intra-station, intra-breeds variation. Data for heritability estimates of percent complementary milk was collected on 81 daughters from 29 sire families of 3 breeds. After regular milking 0.5cc of an oxytocin solution containing 10 U.S.P. units was administered. The heritability estimate calculated from the correlation among half-sibs was 34–40%.

14. MUCOPOLYSACCHARIDOSIS IN SNORTER DWARF CATTLE. M. Koger, A. C. Warnick, J. F. Hentges and A. E. Lorincz, *University of Florida, Gainesville.*

The snorter dwarf in cattle has certain characteristics analagous to the human form of dwarfism known as the Hurler Syndrome (gargoylism, lipochondrodystrophy). The Hurler Syndrome is characterized by an excretion of acid mucopolysaccharide in the urine and by an accumulation of these compounds in certain tissues. Consequently, appropriate chemical isolation and identification of the urinary acid mucopolysaccharide excretion was determined for snorter dwarfs, known carriers, and assumed

non-carriers of the trait. Preliminary results showed dwarf animals to excrete high levels of acid mucopolysaccharide while non-carriers excreted little or insignificant amounts. Known carriers appear to excrete intermediate amounts. Subsequent histological and chemical analyses of liver and other tissues demonstrated abnormally large accumulations of acid mucopolysaccharide in the tissues of dwarf animals.

15. FACTORS ASSOCIATED WITH WOOL PRODUCTION OF RANGE COLUMBIA, RAMBOUILLET AND TARGHEE EWES. Milton A. Madsen and Arthur B. Chapman, *Utah State University, Logan, and University of Wisconsin, Madison.*

Weaning and wool production records of range Columbia, Rambouillet and Targhee ewes collected over a 10-year period were studied. The traits measured were: weanling body weights and staple lengths; yearling grease fleece weights, clean fleece weights, and staple lengths; two-year-old fall body weights, grease fleece weights, and staple length. The effects of the following factors were studied: year, generation, age of dam, type of birth and rearing, age at weaning, and two-year-old body weights. These factors accounted for 16 to 50% of the observed variance in the yearling and two-year-old traits. Body weights of both lambs and two-year-old ewes and grease fleece weights were the traits influenced most by the factors studied. Phenotypic correlations between body weights and staple lengths were low and not significant. All other correlations were significant and positive. Correlations between repeated measurements of the same trait varied from 0.26 to 0.69. Heritability estimates were computed by doubling the regression coefficients of offspring on dam. Estimates for each of the traits measured for Rambouillet, Targhee, and Columbia, respectively, were: mature body weight, .38, .28, .44; two-year-old grease fleece weight, .05, .24, .37; two-year staple length, .35, .19, .30; yearling fleece weight, 0, 0, .35; yearling staple length, .24, .13, .17; weanling staple length, .01, .16, .46; weaning body weight, .06, .17, .16.

16. RELATIONSHIP BETWEEN CARCASS TRAITS USED IN A BEEF SELECTION PROGRAM. W. T. Magee, L. J. Bratzler, R. J. Deans and A. M. Pearson, *Michigan State University, East Lansing.*

The spark for this report was kindled last year when the bull with the highest loin eye area had the smallest percent (round and loin) and vice versa. Thus the relationship between several carcass traits was investigated in 31 steers tested in 1956 and 1957, 5 bulls tested in 1959, and 12 bulls tested in 1960. All animals within a year were handled as near alike as possible. They were slaughtered as yearlings at an average weight near 900 lb. The correlation between loin eye area and percent (round and loin), on a carcass basis was: —.53 for steers, —.86 for 1959 bulls and 0.17 for 1960 bulls. Carcass weight had a consistent effect on percent (round and loin). The correlation between these two traits was —.37, —.50 and —.59 for the three groups, respectively. In the 1960 bulls the correlation between loin eye and percent round and percent loin, independent of the effect of carcass weight, was 0.50 and —.14 respectively. The correlation between percent round and percent loin was —.23. The correlation between the left and right side for percent loin, round and hind quarter was 0.47, 0.77, and 0.78, respectively. The correlation between tenderness index and loin eye area was —.30. Bulls have been selected for 2 years on the basis of their carcass characteristics. Those selected for tenderness were 0.5 below average on loin eye area and those selected for desired shape were 2.4 below average on tenderness.

17. EARLY SELECTION OF BEEF CALVES. D. C. Meyerhoeffer, R. C. Carter and B. M. Priode, *Virginia Agriculture Experiment Station, Blacksburg, and Agriculture Research Service, USDA.*

The effectiveness of selection of beef calves at mid-summer was compared with selection at normal weaning date using data from 536 Angus, 556 Hereford and 590

Shorthorn calves born during the 9-year period, 1950 through 1958, at the Beef Cattle Research Station, Front Royal, Virginia. Estimates of heritabilities and genetic correlations were obtained from paternal half-sib variance and covariance components analysis. The traits studied were daily gain from birth to mid-summer (Y_1), mid-summer to weaning (Y_2), birth to weaning (Y_3), type score at midsummer (Y_4) and type score at weaning (Y_5). Heritability estimates obtained for these traits were 0.18, 0.25, 0.22, 0.27 and 0.21, respectively. Positive genetic correlations less than 0.2 were obtained between Y_1 Y_5, Y_3 Y_4, Y_3 Y_5. Positive genetic correlations between 0.2 and 0.4 were Y_1 Y_2, Y_1 Y_4, Y_2 Y_4, Y_2 Y_5, and greater than 0.7 were Y_1 Y_3, Y_2 Y_3, Y_4 Y_5. Phenotypic correlations were obtained by the standard product moment correlation method and were generally higher than the genetic correlations. Rank order correlations were obtained within sire groups containing five or more calves on daily gain and type at mid-summer with mid-summer to weaning daily gain and type at weaning. The average rank correlation for daily gain from birth to mid-summer with mid-summer to weaning was 0.41, for daily gain from birth to mid-summer with birth to weaning 0.82 and for type at mid-summer with type at weaning 0.69.

18. FACTORS INFLUENCING WEANING WEIGHT OF BEEF CALVES. J. A. Minyard and C. A. Dinkel, *South Dakota State College, College Station.*

The weaning records of 2351 calves representing 120 sires were analyzed in a study of factors influencing weaning weight. The data were collected from 1951 through 1957 in 20 purebred Hereford and Aberdeen-Angus herds. Two methods of calf age adjustment, sex of calf effects, and age of dam effects, as well as the heritability and repeatability of weaning weight, were evaluated. The two methods of age adjustment were (1), daily gain to weaning $\times$ 190 + birth weight and (2), actual weaning weight $\times$ appropriate multiplicative factor calculated from weaning weights of calves raised under conditions similar to those of this study. Age adjustment No. 2 was the most efficient, removing 90% of the variance due to age of calf. Sex of calf was shown to have a highly significant influence on weaning weight. Evaluation of bull and heifer means (409 and 375), standard deviations (46 and 42), and coefficients of variation (11.19 and 11.11) suggest the use of a multiplicative factor, $\overline{X}_B/\overline{X}_H$, for sex adjustment. However, since they were convenient to apply, both additive (+34) and multiplicative factors computed by ranch and year were compared. The multiplicative factor used was more effective. However, neither method reduced the between sex variance to a non-significant level. The influence of age of dam on calf weaning weight was highly significant. Adjustment factors were computed by two methods, by averaging all records made at each age and by comparing the records of consecutive calves from the same cow. Maximum production was reached at eight years of age. The cows were grouped as 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13 or over. Deviations from the eight-year-old group were —69, —33, —21, —13, —4, —3, 0, —9, —23, —24, —38 and —41, respectively. Repeatability of weaning weight was estimated as the intra-class correlation of adjacent weaning weight records of the same cow and in this study was 0.42. Heritability of weaning weight was estimated within ranch-year subclasses by the paternal half-sib correlation method. The estimate obtained was 0.32 with fiducial limits of 0.21 and 0.47.

19. INFLUENCE OF SIRE, DAM'S MILK PRODUCTION, THREE LEVELS OF NUTRITION AND OTHER FACTORS ON 120- AND 240-DAY WEIGHT OF HEREFORD CALVES. W. E. Neville, Jr., D. M. Baird and O. E. Sell, *Georgia Experiment Station, Experiment.*

Over a 3-yr. period, 120 and 240-day wt. were obtained on 135 Hereford calves by 5 sires. Approx. 6 wk. prior to calving in Dec. the cows were on three levels of nutrition until the calves were 4 mo. old; subsequently the nutrition levels were similar. The LP (low plane) received grass silage + 1 lb. c.s. meal, MP received

corn silage + 1 lb. c.s. meal and HP received limited winter pasture in addition to the MP ration. Milk prod. of the cows was estimated by wt. differences of their calves before and after nursing. Milk wt. were obtained twice a day, four times (about every 2 months) between birth and weaning at 8 mo. Greatest sire effects on calf wt. differences, as determined by least squares independent of milk prod. effects, in 4 mo. and 8 mo. calf wt. were 14.2 and 28.4 lb., resp. Av. daily milk prod. of cow up to 4 mo. and 4 mo. calf wt. corrected for sire and sex effects were: LP=8.5, 218; MP=10.2, 251; HP=11.5, 273 lb., resp. Similar figures for milk up to 8 mo. and 8 mo. calf wt. were: LP=8.1, 400; MP=9.6, 448; HP=10.5, 461 lb., resp. Regression of 8 mo. calf wt. on dam's milk prod. in 100-lb. units was 8.65, 8.12, 5.60 for LP, MP, and HP calves corrected for year, sire and sex effects. All three b values were sig. different. Daily milk prod. and daily gains of calves were obtained for the four 60-day periods. The b of daily calf gains on daily milk prod. and their r for the four consecutive periods within year, nutrition, sex and sire were as follows: .064, .70; .055, .61; .044, .63 and .048, .64 for b and r resp. A within year, nutrition, sex and sire value of .798** was obtained when total milk prod. was correlated with 8 mo. calf wt.

20. USE OF OWNER SAMPLER RECORDS IN SIRE EVALUATION. G. V. O'Bleness, L. H. Wadell and C. R. Henderson, *Cornell University, Ithaca, New York.*

To obtain proofs on sires used in artificial insemination at the earliest possible date it might be desirable to make use of Owner Sampler records in computing daughter averages. For the Holstein breed there were 31 A.B. sires having at least 15 Owner Sampler daughters. The predicted correlation between the production of these sire's Owner Sampler daughters and their D.H.I.A. daughters was 0.87 assuming equal heritability of 0.22 for both groups of records. The observed correlation between the adjusted daughter average production of these two groups was 0.84 for milk and 0.77 for fat. The adjusted daughter average of the Owner Sampler records was 12,134 lb. of milk and 442 lb. of fat. These same D.H.I.A. averages were 12,192 lb. and 444 lb. There is no evidence from these data that Owner Sampler records should not be used in sire evaluation.

21. RELATIONSHIP OF FEED EFFICIENCY AND RATE OF GAIN WITHIN SPECIFIC 100-POUND WEIGHT INCREMENTS IN GROWING BEEF CATTLE. C. C. O'Mary, Douglas D. Bennett and M. E. Ensminger, *Washington State University, Pullman.*

Sixteen bulls and 33 heifers were individually fed for 150 days on an all-pelleted ration consisting of 50% alfalfa and 50% concentrates. Correlation coefficients were determined between feed efficiency (total feed per cwt. gain) and rate of gain for a time-constant test of 150 days and also within specific 100-lb. weight increment increases. Each bull and heifer was not tested through all 100-lb. weight increments. Feed efficiency and rate of gain were significantly correlated in bulls within all weight increments tested. Eleven bulls were tested from 600 to 700 lb. (r=—.74), thirteen bulls from 700 to 800 lb. (r=—.82) and five bulls from 800 to 900 lb. (r=—.81). Feed efficiency and rate of gain were significantly correlated in heifers only within the 600- to 700-lb. weight increment (n=19, r=—.59). Other weight ranges tested in heifers were 400 to 500 lb. (n=11, r=0.15), 500 to 600 lb. (n=17, r=—.45) and 700 to 800 lb. (n=6, r=0.16). The data indicate that selection for feed efficiency based on rate of gain probably would be more reliable with weight-constant tests than with time-constant tests, if the appropriate weight intervals are selected.

22. SEX AND SIRE INFLUENCES UPON THE 270-DAY WEANING WEIGHTS OF SOUTHWESTERN RANGE CALVES. O. F. Pahnish, E. B. Stanley, Ralph Bogart and C. B. Roubicek, *The University of Arizona, Tucson, and Oregon State College, Corvallis.*

Evaluations of sex and sire influences were based upon the weaning weights of 329 bull progeny and 332 heifer progeny produced by 11 sires on two ranches in 6 years. The first three crops of purebred Hereford calves were produced on ranch I. Following a division of the herd on the basis of individual performance records, the last three crops were produced on ranches I and II. Prior to analyses, all weights were adjusted to a mean age of 270 days and to a constant age of dam basis by factors previously reported. Sex influences were evaluated by variance analyses for multiple classifications with disproportionate subclass numbers. On ranch I, over the six-year period, weaning weights were influenced significantly ($P<.01$) by sex, year and sex X year. When the data from ranches I and II over the last 3 years were combined, influences of sex, ranch and year were highly significant while sex x ranch and ranch x year interactions were significant ($P<.05$). When all data were combined (2 ranches and 6 years) the sex x sire interaction within ranches and years was non-significant. Heritability estimates for weaning weight were computed within sex of progeny by the paternal half-sib method with statistical removal of year and ranch effects. The resulting estimates with approximate 95% confidence intervals, from the data on bull and heifer progeny, respectively, were 0.28 ± 0.32 and 0.57 ± 0.41. The difference between estimates was considered non-significant because of the wide overlap of confidence intervals.

23. A COMPARISON OF MASS SELECTION AND INBRED LINES AND LINE CROSSES IN THE LABORATORY RAT. David R. Pratt and W. T. Magee, *Michigan State University, East Lansing.*

Inbred lines of rats were developed by mating sons, double-sons and triple-sons back to their dams. Four lines were developed from a two-strain base population and four lines from a three-strain base population. A selected line was developed from each of the base populations. Selection was made on the basis of gain from weaning (21 days of age) to 50 days of age. Crosses were made between the inbred lines within each of the groups and comparisons of the inbreds and the line crosses were made with the selected lines of each group. Average litter size at birth was smaller in the inbred litters than in the selected litters in both the two- and three-strain groups. In the two-strain group average litter size at birth of the selected lines (12.0) was significantly higher than the average of the line crosses (5.6). In the three-strain group, average litter size at birth was slightly higher in the line cross litters (8.3) than the selected line (7.4). All litters were culled to eight at five days of age and viability to weaning was thus difficult to measure; however, the two-strain line cross litters were significantly smaller at weaning than the selected line. (In addition to being smaller at birth, four litters weaned no rats.) No hybrid vigor was exhibited in gains from the line cross litters when compared to the selected lines of the same group.

24. A COMPARISON OF PERFORMANCE OF CROSSBRED PIGS SIRED BY INBRED AND HYBRID BOARS. W. E. Rempel, Frank Enfield and R. E. Comstock, *University of Minnesota, St. Paul.*

Progeny of eight three-way cross boars [Minn. No. 3 (Minn. No. 2 x Minn. No. 1)] were compared with progeny of four Minn. No. 3, two Minn. No. 2 and two Minn. No. 1 boars. Dams were comparable groups of Minn. No. 1's. Six replicates of pigs sired by inbred and crossbred boars were fed-out from after weaning age to an end

weight of 200 ± 10 lb. in two separate barns. Pigs sired by inbred boars were lotted so that each pen contained 50% No. 3-sired pigs, 25% No. 2-sired pigs and 25% No. 1-sired pigs in an attempt to equalize the breed composition of pigs by the two classes of sires. Pigs within sex and breed of sire were assigned randomly to their pens. The daily gain of 236 pigs sired by hybrid boars was 1.85 lb., compared with a daily gain of 1.91 lb. for 221 pigs sired by inbred boars. The feed per hundred pounds gain was 372.8 lb. and 371.2 lb. for pigs sired by hybrid and inbred boars, respectively. The carcass data for 56 barrows sired by hybrids and 57 by inbreds were very similar. The small, but insignificant differences in performance were consistently in favor of the progeny of inbred boars. The present data seem to justify the conclusion that hybrid boars will sire pigs comparable in performance to the average performance of pigs sired by breeds of boars from which the hybrids were constituted. The single cross pigs in this study largely reflect the performance of the parent breeds that went into the cross.

25. A GENETIC ANALYSIS OF WEANING WEIGHT OF FRYER RABBITS. W. C. Rollins and R. B. Casady, *University of California, Davis, and U. S. Rabbit Experiment Station, Fontana, California.*

Data from approximately 6,000 rabbits raised during the past 17 years at the U. S. Rabbit Experiment Station have been studied. Sex, size of litter in which a rabbit was weaned and season of weaning had little effect on weaning weight. Weaning weights were lighter in a doe's first litter and in her later litters (numbers 11 and up) than in her intermediate litters. Data for 3,244 rabbits were amenable to analysis in a polyallel design. The data were divided into three blocks by year groupings. A doe's first litter and litters number 11 and up were excluded. With these restrictions Henderson's method 1 (Biometrics, 1953) was applied in parallel analyses to the three blocks of data. The results of the three analyses are in good agreement; their unweighted average gives the following variance component estimates: Bucks (B), 0.015; does (A), 0.031; bucks x does (BA), 0.063; within litter (W), 0.150. If the theoretical composition of the variance components is taken to be $B = \frac{1}{4} G$; $A = \frac{1}{4} G + C$; $BA = \frac{1}{4} D$; and $W = \frac{1}{2} G + \frac{3}{4} D + E$, where G = additively genetic variance, D = variance due to dominance deviations, C = variance due to maternal effects and E = variance due to random environmental causes, then a large negative estimate is obtained for E. To explain this situation, a tentative hypothesis is that the variance component BA contains an additional component HC which represents the variance associated with interactions between genotypes and maternal effects.

26. VARIABILITY CONSIDERATIONS WHEN USING PRODUCTION-TESTED CATTLE IN A FEEDING EXPERIMENT. G. C. Scott, S. M. Free, Jr. and S. F. Scheidy, *Smith Kline & French Laboratories, Philadelphia, Pa.*

While considering plans for future nutrition studies, results of several previous studies were reviewed for estimates of inherent variation. All work included studies of similar duration (approximately 90 days) conducted with cattle of approximately the same starting weight. One of the seven studies reviewed was conducted with production-tested animals. The inherent variation in this group was considerably smaller than that for all other experiments. Considering the detection of treatment differences when final weight and total gain are the indexes measured, one finds that 10 production-tested cattle provide the same precision as 17 head in the next best study or 90 head in the most extreme study. Graphs were developed to show the number of animals required to show statistical significance over a wide range of average differences between two treatments. Data from all seven studies are included in the comparisons. In addition, the probability of failure to show a real difference to be statistically significant is also considered.

27. A COMPARISON OF THE OVULATION RATE AT FIRST THREE HEAT PERIODS OF ANGORA DOES. Maurice Shelton, *Texas Agricultural Experiment Station, McGregor.*

Previous work has shown that Angora does do not normally start to cycle until males are placed with them in fall of year. Thus, they are normally bred on the first heat period of season, and it is important to know if fertility would be higher at heat periods subsequent to the first one. This question was investigated during the 1958 and 1959 breeding seasons. In the fall of 1958 a total of 56 does were bred on the first heat of the season. These does dropped 80 kids for an average kidding rate of 142.9%. Forty-six does were bred on the second heat period. These does dropped 78 kids, an average kidding rate of 169.6%. In 1959 matings were made on first, second and third heat periods of the season. Yearling does had average kidding rates of 122.2 (9), 142.9 (7) and 114.3 (14) for the first three heat periods, respectively. Similar data for aged does were 165.2 (23), 175.9 (29), 145.8 (24). (The number in parenthesis indicate the number of does in each group.) A similar comparison was made on a group of grade does which were slaughtered after mating to determine ovulation rate. The ovulation rates were 1.03 (34), 1.24 (21) and 1.20 (6) for the first three consecutive heat periods. These does had been bred to fertile males and ovum was recovered from a portion of these does. Only 85.2% of the ovum collected from does bred on first heat was classified as fertile, compared to 100% for those bred on the second and third heat.

28. PERFORMANCE OF STRAIGHTBRED AND CROSSBRED SWINE. H. J. Smith, R. P. Moorman and J. B. McLaren, *University of Tennessee, Knoxville.*

The performance of straightbred (Duroc, Hampshire, Poland and Landrace) and crossbred litters were studied to compare the productivity of straightbreds with various two-, three- and four-breed crosses among the straightbreds. Performance characteristics studied were: litter size at birth, 56, 154 and 180 days; weight per pig at birth, 56, 154 and 180 days; weight per litter at birth, 56, 154 and 180 days; daily gain from birth to market; and probe backfat measurement at 200 lb. Crossbred sows (two- and three-breed crosses) farrowed 9 to 11% more pigs than straightbred sows, and crossbred sows also were superior in litter size at all other ages. Two-, three- and four-breed cross litters were 13, 34 and 20% larger, respectively, at market time than straightbred litters. Most of the advantage of two-breed cross litters was due to the greater survival ability of the crossbred pigs while the advantage for the three- and four-breed cross litters reflected both greater litter size at birth and greater survival ability of crossbred pigs. Crossbred pigs gained faster from birth to market and were from 6.1 to 8.1% heavier at 180 days than straightbred pigs. Crossbred litters were significantly heavier than straightbred litters at 154 and 180 days reflecting the effects of greater pig survival and growth ability in crossbred litters.

28a. INVITATIONAL PAPER—CORRELATING RESULTS FROM BEEF BREEDING RESEARCH. H. H. Stonaker, *Colorado State University, Fort Collins.*

29. CORRELATIONS OF VARIOUS FACTORS WITH THE SALE PRICE OF PERFORMANCE TESTED AND NON-PERFORMANCE TESTED BEEF BULLS. J. C. Taylor, J. C. Dollahon, H. G. Travis and C. E. Lindley, *Mississippi State University, State College.*

Sale records were available on 129 bulls sold following a 140-day feeding trial over a 3-year period in which the buyers were furnished with information which consisted of final weight, final grade, weight per day of age, gain on test and index. Each sale consisted of Angus, Hereford, Shorthorn, Polled Hereford and Santa Gertrudis

bulls; the sales were conducted at the University. In addition, sale records were kept on 228 bulls of the Hereford and Angus breeds sold in private or association sales held in various parts of the state. Information made available to the buyers at these sales consisted of either part or all of the above information. Pedigrees were also available in all sales but were not considered in the study. For the Angus and Hereford, which represented the majority of the bulls sold, highly significant correlations of 0.54 and 0.60 were obtained between sale price and final weight respectively. Highly significant correlations of 0.53 and 0.63 were obtained between sale price and type grade respectively. Lower correlations of 0.03 and 0.10 were found between sale price and daily gain on test for the Angus and Hereford, respectively. Highly significant correlations of 0.26 and 0.41 between final weight and type grade were obtained for the Angus and Hereford, respectively. Correlations between final weight and daily gain, type grade and daily gain ranged from 0.02 and 0.08 for both breeds.

30. ESTIMATES OF PARAMETERS OF GROWTH IN BEEF HEIFERS. J. W. Thornton, J. A. Gaines and C. M. Kincaid, *Virginia Agricultural Experiment Station, Blacksburg, and Agricultural Research Service, USDA.*

Data on 646 beef heifers, 214 Angus, 175 Herefords and 257 Shorthorns, collected at the Beef Cattle Research Station, Front Royal, Virginia, from 1950 through 1958, were used to estimate genetic, phenotypic and environmental parameters of growth for birth weight (y_1), preweaning growth rate (y_2), feed lot gain (y_3) and pasture gain (y_4). A breed-growth period interaction made it necessary to estimate the parameters within breeds. Adjustments were made for three fixed effects, year, age of dam, and birth month of calf, using the least squares method employing matrix arithmetic. Heritability estimates determined from paternal half-sib analysis for y_1, y_2, and y_3 were: $0.13 \pm .16$, $0.21 \pm .12$, and $0.12 \pm .08$, respectively, for Angus; 0, $0.13 \pm .14$, and 0, respectively, for Herefords; $0.21 \pm .13$, $0.25 \pm .16$, and $0.22 \pm .16$, respectively, for Shorthorns. Genetic correlations greater than 0.40 were found for y_1y_2 and y_2y_3 in the Angus breed and for y_1y_2, y_1y_3 and y_1y_4 in the Shorthorn breed. A genetic correlation of $-.50 \pm .36$ was found for y_2y_3 in the Shorthorn breed. Environmental correlations greater than 0.20 were found for y_1y_2 and y_1y_3 in the Angus, and y_2y_3 and y_3y_4 in the Shorthorns; they were greater than $-.30$ between y_2y_3 in the Angus, and y_1y_2 and y_3y_4 in the Shorthorns. Phenotypic correlations were less than 0.3 in all breeds. Data on 145 full-sibs indicated that maternal environment accounted for 30% and 20% of variation in y_2 in the Angus and Hereford breeds, respectively.

31. ULTRASONIC MEASUREMENT OF FATNESS IN SWINE DURING THE GROWING-FATTENING PERIOD. W. E. Urban and L. N. Hazel, *Regional Swine Breeding Laboratory, ARS, USDA, and Iowa State University, Ames.*

An ultrasonic device was used to measure the amount of backfat on swine at weaning, at each of three 4-week periods thereafter, and at slaughter weight of 200 lb. The experimental animals consisted of 75 pigs of which 25 were gilts and 50 were barrows, and included five breeds and one breed cross. Measurements were taken at three sites and summed. Both the depth to the longissimus dorsi and the depth to the fascia were recorded at each measurement time, the pigs also being probed at 200 lb. with a ruler probe. All measurements other than those taken at slaughter weight were adjusted for differences in body weight by linear regression. Curves for fat deposition were plotted against both time and body weight and were found to be essentially linear during the period studied. The correlations between the amount of fat on one day and the amount of fat 4 weeks later were generally positive but lacked statistical significance, however. Observations on various production and carcass traits were obtained and related to fatness. Fascia depth was not as good an indicator of the production and carcass traits as was total depth. Generally, the ultrasonic probe was

not as good as, or at least was no better than, the mechanical probe for predictive purposes. Early measurements of fatness were of little value for predicting carcass quality, although the measurement taken an average of 4.9 weeks before slaughter shows promise.

32. REGRESSION FACTORS FOR EXTENDING PART LACTATION RECORDS. L. D. VanVleck and C. R. Henderson, *Cornell University, Ithaca, New York.*

Regression factors for extending part lactation milk records are developed from the within herd analysis of age and season corrected monthly test day records of 9,036 Holstein cows in 374 herds. Best single months for estimating lactation yield are the fourth, fifth, and sixth months. The correlation between predicted actual record is 0.85 for testing in those months. If sequential monthly tests are used for prediction, the multiple correlation of the first five monthly tests with complete lactations is 0.92, for six months 0.94, and for seven months 0.96. Factors developed from the cumulative test day production are slightly less accurate. The correlation of the sum of the first seven monthly tests with total production is 0.95. Bimonthly tests when extended with multiple regression factors are highly correlated with total lactation yield. The multiple correlations for both bimonthly testing possibilities are 0.98. Estimates based on cumulative bimonthly test records are also highly correlated (0.98) with complete yield. Correlations between cumulative trimonthly tests and complete yield ranged from 0.92 to 0.96. Bimonthly testing appears satisfactory for use since the accuracy of prediction is extremely high and since the cost of a bimonthly testing program should be lower than existing once a month programs.

33. EFFECT OF CROSSBREEDING ON REPRODUCTIVE PERFORMANCE OF DAIRY CATTLE. Frank A. Verley and Robert W. Touchberry, *University of Illinois, Urbana.*

The object of this study was to make unbiased comparisons of the reproductive performances of purebred and crossed animals. The seven measures used, services per conception, age at first calving, interval from first service to conception, gestation length, calving interval, calving date to first heat, and calving date to first service were recorded, as unselected data on the first generation female progeny in the University of Illinois Dairy Crossbreeding Project. The 86 animals included in the study were sired by four bulls, two Holsteins and two Guernseys, and consisted of 26 Holsteins, 21 Crossbreds (H♂ x G♀), 23 Crossbreds (G♂ x H♀) and 16 Guernseys. The analyses involved orthogonal comparisons of the sub-class means and the differences were tested for statistical significance by the use of a t-test. Because the numbers of animals in the various subgroups were unequal, it was necessary to use an inverse matrix in the analysis of the data in order to provide unbiased estimates of the standard errors of the various effects. Partial confounding of the effect of service sire with breed of sire, breed of dam, and sires within breed did not permit interpretation of the significant differences observed. For the seven measures used, estimates of the effect of system of mating were consistent, small and non-significant. This evidence supports the concept of the relative unimportance of non-additive gene action in effecting variation in measures of reproductive performance.

34. BIASES IN ESTIMATING REPEATABILITY OF MILK AND BUTTERFAT PRODUCTION. L. H. Wadell, *Iowa State University of Science and Technology, Ames.*

The 13,747 D.H.I.A. lactation milk and butterfat records of 4,836 Holstein dairy cows in 15 Iowa State Institutional herds were studied to compare and show the

application of two methods of estimating repeatability with inquiry into why these two methods gave slightly but significantly different results. Method one is a weighted combination of three different estimates of repeatability, each derived from a simple regression coefficient. Method two is the intraclass correlation obtained as a ratio of variance components computed from an analysis of variance of all records. Intraherd intraclass correlations were 0.427 ± 0.011 for milk and 0.392 ± 0.011 for fat. Corresponding values computed by method one were 0.502 ± 0.014 for milk and 0.482 ± 0.014 for fat. Method one gave intrayear intraherd values of 0.516 ± 0.019 for milk and 0.497 ± 0.019 for fat. Intrayear intraherd intraclass correlations were 0.421 ± 0.011 for milk and 0.408 ± 0.011 for fat. The differences observed between the repeatability values obtained by these two methods are thought to be due to (a) an adjacency factor and/or (b) bias which selection has introduced into the computed intraclass correlation. Evidence is given which shows that under the truncation type of selection the repeatability computed from the intraclass correlation is biased.

35. RELATIONSHIPS BETWEEN SHADE-OF-RED, FEEDER GRADE, AND GAINS IN HEREFORD STEERS. J. D. Wheat, L. A. Holland and E. F. Smith, *Kansas State University, Manhattan.*

Hereford steers were independently scored for intensity of red and feeder grade in April, 1956 and 1957—beginning of summer grazing season. At end of season, (October), fall feeder grades were determined for the 136 steers used in 1956 and in November for the 155 steers used in 1957. Fall color was scored only for 1956 steers. Each year steers were wintered as a group in dry lot. Darkest colored steers received highest color scores. In 1956, lighter colored steers in April had higher feeder grades in fall; correlation was —.24, but it was only —.01 in 1957. Repeatability of color score in April (correlation between scores given the same animal by different scorers) was 0.74 in 1956 and 0.73 in 1957. Repeatability of spring feeder grade was 0.57 each year. Only statistically significant correlation between shade-of-red and gain (winter, summer, and total) was —.20 between April color score and total gain the first year. Significant correlations between feeder grade and gain were those involving grade and gain during preceding period such as spring feeder grade and winter gain, and fall grade and summer gain. Average correlations were 0.17 and 0.22. Gains, such as winter and total, and summer and total, representing part-whole relationships were significantly correlated. Average values were 0.72 between winter and total, and 0.64 between summer and total.

36. GENETIC AND LACTATIONAL INFLUENCES ON GROWTH AND MATERNAL TRAITS. C. W. Young and J. E. Legates, *North Carolina State College, Raleigh.*

A cross-nursing study was conducted with mice to determine the relative importance of prenatal and postnatal effects on variability of individual weights taken at birth, 12 days, 21 days, 42 days, and 56 days of age. The cross-nursed females were also allowed to raise their own litters and the prolificacy and postnatal maternal performance of these females were analyzed to assess the importance of the direct and transmitted effects of their dams upon these traits. Each cross-nursing group consisted of three females and their litters which had been dropped within a 12-hour period. Litters were reduced to six young, and two young from each litter were placed with each of the three dams. Three experiments were conducted and these results are based upon the combined analyses of 49 cross-nursing groups from these experiments. Prenatal influences due to genetic and uterine differences accounted for 38, 11, 12, 18 and 18% of the total variance in individual weights taken at birth, 12 days, 21 days, 42 days, and 56 days of age, respectively. Postnatal influences, largely lactational, accounted for 0, 63, 61, 22, and 16% of the variance in the same traits.

Hence, the dam's milk production accounted for almost two-thirds of the total variance in individual weights of young mice at 12 days and 21 days (weaning) and remained a major source of variation until maturity. However, the lactational performance of the dam apparently has little direct effect upon subsequent prolificacy or lactation of her female progeny as postnatal effects accounted for 1% or less of the variance in these traits.

37. LIVE ANIMAL VALUES AND CARCASS MEASUREMENTS AS INDICATORS OF MEATINESS AND QUALITY IN BEEF CATTLE. W. R. Backus, J. C. Dollahon, J. C. Taylor, G. C. Williams and H. G. Travis, *Mississippi State University, State College.*

Live animal values and carcass measurements were collected on 293 steers which had been subjected to four different feeding regimes. Carcass measurements as outlined by the Proceedings of the Fourth Annual Reciprocal Meats Conference were taken. Correlations were calculated separately for each of the four groups of steers. Average ribeye width was highly significantly correlated with ribeye area and ranged from 0.54 to 0.88. Correlations of the average ribeye width with the circumference of the round were 0.25 to 0.44. Thickness of fat over the 12th rib was significantly correlated with carcass grade, but approached zero when correlated with all other measurements. Rate of gain on test was more highly correlated with carcass length than with any other observation and was of the order of 0.45. Length of carcass and length of leg was highly significantly correlated with length of loin, circumference of the round, width of chest, depth of chest at both the fifth and seventh rib, average ribeye width, ribeye length, ribeye area, and width of round. Correlations of length of loin with circumference of the round, width of chest, average ribeye width, and ribeye area were low, whereas higher correlations were found with depth of chest at the fifth and seventh rib and width of round. Circumference of the round was highly significantly correlated with width and depth of chest, average ribeye width, ribeye length, ribeye area and width of round. Depth of chest at fifth and seventh rib was highly significantly correlated with ribeye area.

38. EFFECTS OF PYRIDINE-RELATED COMPOUNDS ON THE PHOTO-OXIDATION OF NITRIC OXIDE MYOGLOBIN. Milton E. Bailey, Richard W. Frame and William C. Stringer, *University of Missouri, Columbia.*

Model systems and cured meat slices were used to determine the stability of nitric oxide myoglobin pigments in the presence of several N-ring compounds including niacin, nicotinamide and pyridoxamine. Evidence was obtained which indicated that "cured-meat pigments" of ham and loin slices treated with pickles containing N-ring compounds, certain orthophosphates, and reducing agents were more desirable and more stable to fluorescent light than "cured-meat pigments" of slices treated with pickles which did not contain the N-ring compounds. Nitric oxide pigments of ham slices treated with pickles containing 0.05 M orthophosphate buffer at pH 6.8 were more stable to flourescent light than those containing 0.05 M orthophosphate buffer at pH 6.2.

39. INFLUENCE OF MUSCLE FIRMNESS ON FRESH MEAT STABILITY. Eugene Birmingham and H. D. Naumann, *University of Missouri, Columbia.*

Loins from 20 beef carcasses and 36 pork carcasses were divided into two and three firmness groups, respectively. Slices of the *longissimus dorsi* were prepackaged and stored under continuous 65 footcandles of light at 34° F. and 50° F. for 2 and 5 days. Pork with firm lean had lower shrinkage losses, higher taste panel scores, higher pH values, lower microbial counts and greater color stability during extended storage.

The beef results, with certain exceptions, were similar to pork results. The amount of water-insoluble residue of both species varied inversely with per cent drip. The soft and firm lean meat exhibited similar shelf life characteristics up to 2 days storage; thereafter, meat with the firmer lean was more stable.

40.

41. EFFECTS OF VARIOUS LEVELS OF DIETARY LYSINE ON MUSCLE DEVELOPMENT AND CERTAIN BLOOD PHENOMENA OF GROWING SWINE. G. M. Cahilly, R. F. Kelly, C. C. Brooks, J. W. Davis and P. P. Graham, *Virginia Agricultural Experiment Station, Blacksburg.*

An experiment has been conducted to determine the effects produced by dietary lysine when supplemented to a corn-peanut oil meal basal ration at graded levels on various physiological phenomena of growing swine. Pigs averaging 30 lb. body weight were divided into four lots and fed the basal ration supplemented with 0.0, 0.3, 0.6 and 0.9% L-lysine monochloride respectively. The initial protein level was 16%. Both weight and volume of total muscle mass were increased by lysine supplementation. Analysis of the *L. Dorsi* and *Semitendinosus* muscles showed that lysine supplementation increased muscle protein content and decreased muscle water. Little or no change was found in muscle fat or total carcass fat. Specific gravity of the total carcass was higher in the supplemented lots and the lysine level of the muscles, when expressed as a percent of the total muscle protein, was slightly higher. Blood studies showed that pigs on the lysine supplemented rations had a decrease in cell sedimentation rate early in the study. Pigs on the basal ration showed a decrease in both packed cell volume and hemoglobin level. Blood serum protein increased with age and with lysine supplementation. Analysis of serum protein fractions showed pigs receiving lysine supplementation had markedly higher albumin and lower alpha globulin when expressed both in terms of percentage and in terms of grams of total circulating protein. Beta globulin remained essentially unchanged. Gamma globulin appeared lower in the lysine supplemented lots.

42. A STUDY OF INTRAMUSCULAR FAT DISTRIBUTION IN THE *LONGISSIMUS DORSI* FOR PAIRED PORK LOINS. Z. L. Carpenter, R. W. Bray, E. J. Briskey and D. H. Traeder, *University of Wisconsin, Madison.*

Thirty-five pork carcasses, varying in weight and fatness, provided loins which varied in content of intramuscular fat. Samples of the *longissimus dorsi,* representing positions opposite the 7th and 13th rib and 6th lumbar vertebrae from both right and left loins, were analyzed for fat content. The remaining portion of the same muscle provided a composite sample. For the heavy carcasses (220 to 250 lb.), the 13th rib and 6th lumbar positions of the muscle were more accurate indicators of total fat content (moisture free basis) than the 7th rib position; respective correlations with the composite for these two positions were 0.95 and 0.93. The 6th lumbar position of the light carcasses (135 to 180 lb.) possessed a closer relationship with the composite than the other two positions. The data show that there were larger variations in the fat distribution in the *longissimus dorsi* muscle from the lighter weight carcasses. The lighter carcasses contained significantly more intramuscular fat in all positions of the loin. A highly significantly correlation of 0.96 was found between the right and left sides, indicating no difference between paired loins.

43. IMPROVING ESTIMATES OF SEPARABLE LEAN IN BEEF CARCASSES BY USING COMBINATIONS OF CARCASS LENGTH AND LONGISSIMUS DORSI AREAS AT THREE LOCATIONS. J. W. Cole, R. H. Epley, Jr. and L. E. Orme, *University of Tennessee, Knoxville.*

The literature indicates that only a small percentage of the variation in total separable lean is associated with loin eye area at the 12th rib. The purpose of this

investigation was to improve the method of estimating separable carcass lean by use of multiple loin eye area measurements. Areas of the *Longissimus dorsi* muscle at the 12th rib, 5th rib, and last lumbar vertebra were obtained from 51 steers representing 6 breeds and varying in age from 12 to 18 months. Live weight ranged from 650 to 921 lb. and carcass grades from high utility to average prime. Simple correlation coefficients between total separable carcass lean and loin eye area at the 12th rib, 5th rib, last lumbar vertebra, and the average of these three were 0.589, 0.578, 0.390, and 0.681, respectively. When carcass length was multiplied by the average of these three area measurements and correlated with total separable lean, a correlation of 0.728 was obtained. Therefore, multiple area measurements in combination with carcass length were associated with 53% of the variation in separable lean. Furthermore, by combining carcass length with area measurements, a definite improvement in estimating separable lean was demonstrated over any one area measurement or an average of the three loin eye measurements. The same five simple correlation coefficients were made within breed and in most cases the same general improvement occurred.

44. EFFECT OF FAT CONTENT ON PALATABILITY OF BROILED GROUND BEEF. J. W. Cole, C. B. Ramsey and L. A. Odom, *University of Tennessee, Knoxville.*

The preference of six graduate student families and a 5-member trained taste panel for broiled ground beef patties containing 45, 35, 25 and 15% fat were determined. Husbands, wives and the trained panel members independently indicated their preference in each of the six possible paired fat content groups. Each patty also was scored for tenderness, juiciness and flavor. These consumers largely preferred the ground beef containing more than 15% fat. Husbands preferred the 35% fat patties above all others. They preferred the 25% fat level over the 45% fat group and both levels were preferred over the leanest, 15% fat group. Wives indicated little difference in their preferences for the three fattest samples. However, these samples were much preferred over the leanest sample. The trained taste panel preferred the patties in direct proportion to fat content. The 45% fat sample was preferred 67% of the times compared and the 15% fat sample only 27% of the times compared. The sample containing 15% fat scored lowest on tenderness, juiciness and flavor. Scores of the three fattest samples showed no definite trend, but the 35% and 45% fat samples scored significantly higher, with one exception, than the 15% fat sample.

45. A MACRO-PHOTOGRAPHIC TECHNIQUE FOR THE QUANTITATIVE DETERMINATION OF MARBLING AND ITS DISTRIBUTION IN MEAT. C. F. Cook, E. E. Miller and R. W. Bray, *University of Wisconsin, Madison.*

A rapid macro-photographic technique was developed by which marbling can be objectively measured, and a relative distribution index calculated. Thirty rib steaks (*l. dorsi*) were classified into three groups of ten according to their subjective marbling score (high, medium, low) as evaluated by three independent judges. Thirty-five-millimeter black and white photographs were taken of the samples and high contrast positive transparencies were printed from the original negatives. The fat or marbling in the meat appears as transparent spots on the print and the muscle as opaque areas. A light measuring device was developed and used to determine the amount of light that was allowed to pass through the transparent print. Data were obtained on the relationship between light transmission values and chemical fat analyses of the muscle, subjective marbling scores and carcass grade. By scanning the print with a light detecting device, the amount of light passed through a small area of the muscle was measured; from this a distribution index was calculated.

46. RELATIONSHIP OF SHEAR FORCE VALUES TO PANEL SCORES FOR TENDERNESS. Sylvia Cover and Robert L. Hostetler, *Texas Agricultural Experiment Station, College Station.*

Shear force as an objective measurement of tenderness depends for its usefulness on how accurately it reveals variations in tenderness. Tenderness appears to be a very complex quality. Six components have been identified and used for scoring by the panel: softness to tongue and cheek, softness to tooth pressure, ease of fragmentation of muscle fibers, mealiness, apparent adhesion between muscle fibers and tenderness of connective tissue. One-muscle steaks from loin and bottom round from 39 steers were cooked to two internal temperatures by both dry and moist heat. Shear force and panel scores for juiciness and the six components of tenderness were obtained. Shear force seemed to be of little value in determining the toughness of connective tissue or in following its tendering during cooking. Trends in opposite directions for scores for connective tissue and scores for certain characteristics of muscle fibers indicate the difficulty in obtaining a measure of the total tenderness of meat.

47. RAM PROGENY EVALUATION. I A CARCASS STUDY OF SHROPSHIRE, COLUMBIA, SUFFOLK AND HAMPSHIRE-SIRED LAMBS. R. J. Deans and H. A. Henneman, *Michigan State University, East Lansing.*

Carcasses were studied from lambs sired by 2 Columbia, 7 Shropshire, 5 Suffolk and 10 Hampshire rams, each of which was mated to a randomly sorted sample of 8 western ewes. Rams were supplied by various breeder cooperators. In 1956–57, 20 Columbia and 64 Shropshire-sired lambs were studied, these being taken off test at a live weight of 85 to 90 lb. The 1957–58 trials involved 34 Suffolk and 15 Hampshire-sired lambs slaughtered between 90 and 95 lb., and in 1958–59, 94 Hampshire-sired lambs were taken off test at similar weights. Carcass cross sections at the 3rd rib, 12th rib and of the leg, posterior to the aitch bone were measured and the lean components combined as an estimation of carcass muscling. Fatness was similarly estimated and included the kidney knob. Relationships were tested by partial correlation with carcass weight constant. The most closely related factor to the combined lean index for all lambs pooled was the width of the *Longissimus dorsi* at the 12th rib (.52). However, analysis by breeds indicated that the weight of the leg was more closely related to lean in Suffolk (r=.84) and Hampshire (.47) lambs. Non-significant correlations were found between area of *L. dorsi* (12th rib) and area shoulder lean in all lambs combined and only in Shropshire-sired lambs were these two factors related. Poor relationships between area of *L. dorsi* (12th rib) and area of leg lean were found. Percent hindquarter was highly significantly correlated with weight of kidney knob. Length of crutch to breakjoint was negatively correlated with weight of trimmed loin in Suffolks and Shropshires but was not related to weight of trimmed loin in Hampshires.

48.

49. CARCASS EVALUATION, PRODUCTION AND PROCESSING COSTS, AND CONSUMER ACCEPTANCE OF LIGHT WEIGHT AND NORMAL WEIGHT HOGS. Ray A. Field, W. Y. Varney and James D. Kemp, *University of Kentucky, Lexington.*

Growth, feed conversion, carcass data, consumer acceptance, palatability factors, and packer and retailer opinions of light weight hogs were evaluated in this study. Hogs weighing 160 lb. required significantly less feed per hundred pounds of gain at a lower price per pound of gain than hogs weighing 200 lb. However, the heavier hogs made the faster gains. Packers estimated that processing costs were 20% greater for hogs slaughtered under 175 lb. Retailers in general preferred smaller cuts than those they

were merchandising. A significantly greater number of consumers considered cuts from the heavier hogs too fat. No significant differences in flavor were revealed by a taste panel and no significant differences in tenderness were shown by the panel or the Warner-Bratzler shear machine between the two weight groups. Cooking losses with loin roasts from the heavier hogs were significantly higher. Wholesale value per hundred pounds live weight was greater for the light weight hogs.

50. EFFECTS OF FREEZING TEMPERATURE AND STORAGE TIME ON THE ORGANOLEPTIC, CHEMICAL, AND HISTOLOGICAL CHARACTERISTICS OF BEEF. J. J. Guenther, R. L. Henrickson, J. H. Venable and G. V. Odell, *Oklahoma State University, Stillwater.*

The effects of freezing, freezer temperature and length of storage on the organoleptic, chemical and histological attributes of beef steaks were studied. Experimental material consisted of one-inch thick steaks taken from the *Longissimus dorsi* muscle of the short loins of U. S. Good grade steer carcasses. The initial product was characterized by analyzing composite samples from each loin for percent protein, fat, moisture, ash, soluble and non-protein nitrogen. Experimental data included: Shear force values; taste panel ratings for tenderness, flavor and juiciness; cooking losses; percent moisture; press fluid; pH; soluble, insoluble and non-protein nitrogen. Histological observations were made from representative cross and longitudinal sections. The steaks were frozen at temperatures ranging from +15° to —30° F. and tested at 0, 12, 24, 48 hours and 1, 4, 8, and 12 weeks. Results indicated that treatment had little effect on the organoleptic and chemical observations. Qualitywise, the frozen and stored steaks were essentially the same as the fresh unfrozen controls. Histologically, distinct effects were produced by the various treatments. Slow freezing resulted in separation of single muscle fibers and a change in the morphology along the periphery of fibers adjacent to ice crystal areas. Sections from the rapidly frozen samples showed a separation of fibers into groups, but the spatial arrangement of individual fibers closely resembled that of the unfrozen controls. The cell membranes appeared to be intact and no intrafibrillar ice formation was noted.

51. CHEW COUNT AS A MEASURE OF TENDERNESS IN PORK LOINS OF VARYING DEGREES OF MARBLING. G. Harrington and A. M. Pearson, *Cambridge University, England, and Michigan State University, East Lansing.*

In scoring meat samples for apparent tenderness, it is difficult to dissociate tenderness from other quality attributes such as juiciness. The "chew count" has been suggested as a means of focussing the judges' attention on tenderness alone. In this study, judges were asked to chew standard sized samples to "the consistency at which they would normally be swallowed". Pork loins (36) were selected in 18 blocks of two, each pair consisting of a well-marbled loin matched with a relatively poorly marbled loin. Corresponding 1½-inch thick chops from each loin of the block were kept together throughout the experiment, being frozen and thawed, scored, chemically analyzed or cooked by deep-fat frying and sheared or tasted at the same time. Duplicate (i.e., adjacent) samples were included at all sessions, showing the standard error of repeat assessments of the same sample by the same judge to be of the order of 4 or 5 chews. Although one exceptionally tough loin had a chew count of 60, the remainder lay in the range 25 to 47. Marbling scores averaged 3.6 for marbled chops on a 5-point scale compared with 2.3 for the poorly marbled ones, while one-half section of 1-inch cores from the corresponding series required an average of 33.6 and 38.8 chews. Intramuscular fat in the marbled chops averaged 4.8% compared with 2.0% for the poorly marbled. Average Warner-Bratzler shear values were 6.4 and 7.7 lb., respectively. Within block correlations showed chew count and shear to be highly associated ($r=0.92$) and that both these measures of tenderness were associated with the two measures of marbling (score and fat content). For example, the within block correlation of marbling score and chew count was —.61.

52. RELATIONSHIP BETWEEN CARCASS MEASUREMENT AND ORGANOLEPTIC QUALITY IN COMMERCIAL AND COUNTRY CURED HAMS. M. C. Heck and C. J. Brown, *University of Arkansas, Fayetteville.*

Correlation coefficients among carcass measurements and factors of organoleptic quality were calculated for two groups of hams from 24 U. S. NO. 1 butcher hogs. The hams were randomly chosen within carcass for commercial and country curing. Carcass and ham measurements were taken and an organoleptic panel scored cooked center slices of ham for six quality factors. Greater variability in shrinkage during processing and in flavor scores were noted among country cured hams. Chilled carcass weight and yield were positively related to organoleptic quality factors for both cures. Carcass length and loin area appear to be poor indicators of organoleptic quality. Average backfat thickness was significantly related to eating quality of both country and commercial cured hams as indicated by respective r values of 0.71 and 0.75 between the average of organoleptic factors and this carcass measurement. Correlations between yield of ham and the average of organoleptic factors were 0.76 and 0.75, respectively, for country and commercial cured hams. The factor which was most closely related to organoleptic quality was shrink during curing, smoking and aging. The correlation between average of organoleptic factors and shrinkage was 0.90 for country cured hams and 0.72 for commercial cured. These data suggest a slightly closer relationship between carcass measurements and tenderness in commercial cured hams than in country cured.

53. EFFECT OF ANTEMORTEM STRESS ON POSTMORTEM LAMB CARCASS CHARACTERISTICS. H. B. Hedrick and H. D. Naumann, *University of Missouri, Columbia.*

Sixty-four lambs were used to determine the effect of pre-slaughter stress on subsequent carcass characteristics. Stress was induced by varied subcutaneous adrenaline injections. Flank muscles were scored subjectively for color, and pH determinations were made of the *rectus abdominis* and *longissimus dorsi* muscles. Myoglobin determinations were made of samples from the *rectus abdominis* muscle. Muscles from stressed animals were significantly darker in color and lower in hydrogen ion concentration than unstressed animals. Hydrogen ion concentration and color score of the flank muscles were significantly related to the hydrogen ion concentration of the *longissimus dorsi* muscle. Color of muscles was not significantly related to carcass grade. There was a significant inverse relationship between myoglobin content and both pH and carcass grade. Color score and myoglobin content were not significantly related.

54. EFFECT OF ANTE-MORTEM INJECTION OF ENZYMES ON THE TENDERNESS OF BEEF CATTLE. D. L. Huffman, A. Z. Palmer, J. W. Carpenter and R. H. Alsmeyer, *University of Florida, Gainesville.*

Fifty-six crossbred cattle grading U. S. Standard to U. S. Good were randomly divided into eight lots of seven each and injected intravenously 30 minutes prior to slaughter. The treatments were: Lot 1—non-injected control; Lot 2—0.1 ml. physiological saline/lb.; Lot 3—10 mg. crude papain/lb.; Lot 4—10 mg. ashed crude papain/lb.; Lot 5—20 mg. ashed crude papain/lb.; Lot 6—10 mg. denatured crude papain/lb.; Lot 7—0.2 mg. crystalline papain/lb.; Lot 8—0.2 mg. crystalline papain/lb. and 10 mg. ashed crude papain/lb. Club steaks, round steaks and rib roasts were tested for tenderness by Warner-Bratzler shear and taste panel. Ante-mortem and post-mortem inspection failed to reveal abnormalities that would result in condemnation. Livers and kidneys from cattle injected with active enzyme were over tenderized.

Taste panel evaluation of club steaks revealed that Lots 3, 4, 7 and 8 were more tender than Lot 1 ($P < 0.05$). All lots of club steak were more tender ($P < 0.05$) than Lot 1 according to the shear technique. Analyses of tenderness data on rib roast failed to show significant differences; however, the mean scores show the same trends as club steaks. Round steak was cooked by two braising methods. Method A braising showed no significant differences. Taste panel evaluation of method B round steaks showed that Lot 3 was more tender than Lot 2 ($P < 0.05$); Lots 1, 3 and 4 were more tender than Lot 7 ($P < 0.05$). Warner-Bratzler shear determinations of method B braised round steak indicated Lot 3 to be more tender than Lots 1 and 5 ($P < 0.05$); Lots 2, 3, 4, 6 and 8 were more tender than Lot 7 ($P < 0.05$).

55. DIFFERENCES IN SLAUGHTER AND CARCASS CHARACTERISTICS BETWEEN FINEWOOL AND CROSSBRED LAMBS. G. T. King and B. J. Bland, *Texas Agricultural Experiment Station, College Station.*

Seventeen crossbred and 31 Finewool lambs by 16 sires were slaughtered and processed through the Texas A. & M. College Meats Laboratory to study the muscle-bone relationship, effect of sire on tenderness, and differences between crossbred and Finewool lambs. The long bones of the thoracic and pelvic limbs were used for muscle-bone study and a trained taste panel and the Warner-Bratzler Shearr Machine were used for tenderness determinations. There was a positive and significant correlation between bone weights and various carcass maesurements, including area of loin eye and weight per day of age. Metacarpus weight was positively and significantly correlated with the sum of the weights of leg, loin and rack. The three carcass measurements that gave the best indication of muscling were width of legs, length of legs and width of shoulders. These three measures were highly correlated with area of loin eye (r=0.71, 0.45, and 0.81). In this study tenderness was not significantly related to sire or to any of the various carcass measurements. In these 48 lambs the crossbred lambs grew faster, graded higher, dressed higher, and were more tender than were the Finewool lambs. There was no difference in percent of leg, loin and rack of the carcass between these two types of lambs.

56. THE USE OF NATURALLY OCCURRING K^{40} TO DETERMINE THE CARCASS COMPOSITION OF LIVE SHEEP. A. H. Kirton, A. M. Pearson, E. C. Anderson and R. L. Schuch, *Michigan State University, East Lansing, and Los Alamos Scientific Laboratory.*

Ten lambs averaging 40 kg. liveweight were used in a preliminary experiment to determine the usefulness of K^{40} for predicting the composition of the live animal. The Los Alamos four pi liquid scintillation counter was used to measure the gamma activity. Counts were made on the live animal before and after they had been thoroughly washed. The lambs were then slaughtered and the carcasses and the non-carcass components were measured for K^{40} activity. The carcasses were physically separated into fat, lean and bone. After these tissues had been weighed and counted, the fat and lean were ground separately and sampled for chemical analyses. Washing the live animals decreased the mean potassium content from 2.71 to 1.77 gm. per kg. liveweight. Correlations between the estimated potassium content of the live unwashed animal and percent carcass fat, lean and bone were —.79**, 0.51 and 0.86**, respectively. These correlations were lower for the washed sheep and very small for the carcasses. The total lean content of these carcasses were best predicted from liveweight (r=0.90**) or from carcass weight (r=0.91**). When the percent protein in the edible tissue was related to the potassium content of the live unwashed animal, the live washed animal and to the carcass, the correlations were 0.80**, 0.83** and 0.41, respectively.

57. THE EFFECT OF BREED-TYPE AND LEVEL OF FEED ON CARCASS CUT-OUT PERCENTAGES AND COMPOSITION OF WETHER LAMBS. Arlin D. Knight, W. C. Foote and Darrell H. Matthews, *Utah State University, Logan.*

Thirty-two wether lambs (Rambouillet and Suffolk-whiteface cross, average age 150 days) divided equally by breed-type into two feed treatments (fattening and maintenance) were fed for 8 weeks. Analysis of variance indicated most measurements reflecting body size and shape differed significantly between both feed and breed treatments. Carcass cut-out percentages were very similar between breed-types, differing only for shoulder (significantly greater for Rambouillet), and breast (significantly greater for Suffolk-cross). Feed treatment differences were more apparent. Leg and shoulder percentages were significantly larger in the maintenance group; loin and rack percentages were significantly larger in the fattening group, indicating differential deposition of fat. Ether extract/nitrogen and ether extract/ash ratios were significantly wider in the leg, rack, and one-half carcass for the fattening group. The ash/nitrogen ratio was significantly wider for the maintenance group in the rack and one-half carcass, but not for the leg. No breed-type differences were found. *Longissimus dorsi* muscle measurements showed the Suffolk-cross and fattening groups had deeper, rounder, muscles with greater surface area than the Rambouillet or maintenance groups, respectively. Adjustment by regression on body weight removed feed treatment, but not breed-type differences. Measures of fat (specific gravity, ether extract percentage and depth at the 12th rib) differed only between feed treatments. These data indicate that though breed-type differences occurred in body conformation the cut-out percentages, and the ash, nitrogen, and ether extract components of the carcass were very similar. The ash/nitrogen ratio was altered by the nutrient level.

58. SEX EFFECTS ON CARCASS AND PRODUCTIVE TRAITS IN FATTENING BEEF CALVES. Tom Koger, Henry Elliott, F. G. Harbaugh and Ralph M. Durham, *Texas Technological College, Lubbock.*

Implanting weanling bull calves with 84 mg. of stilbestrol had no measurable effect on gain, efficiency or carcass traits. Implanting weanling steer claves with 36 mg. induced marked differences in performance and carcass traits. Thirty-two Hereford bull calves and steer calves were randomly divided into four sub groups. One group of bulls was implanted with 84 mg. of stilbestrol and one group of steers was implanted with 36 mg. The cattle were fed a 60% concentrate all pelleted ration from weaning to 1000 lb. Individual efficiency and gain records were obtained. The two groups of bulls and the group of implanted steers made faster gains, had better efficiency and produced a higher percentage of retail trimmed cuts of chilled carcass weight than did the non-implanted steers. No significant differences were observed between the bull groups or between the bull groups and the implanted steers. Observed differences favored the implanted steers for performance traits and the bulls for carcass traits. The meat was sold as quarters or halves to the college staff. Opinion sampling indicated no unfavorable response to any of the meat as to tenderness, flavor, juiciness, and general desirability.

59. RELATIONSHIP OF GAMMA RAY MEASUREMENTS TO THE LEAN CONTENT OF HAMS. R. Kulwich, L. Feinstein, C. Golumbic, R. L. Hiner, W. R. Seymour and W. R. Kauffman, *ARS, USDA, Beltsville, Maryland.*

The gamma ray radiation from each of 34 hams ranging in weight from 13.2 to 17.2 lb. was measured in a plastic scintillation counter. Simultaneous measurements were made at two gamma ray energy levels, so that the radiation arising from the fission product, Cs^{137}, as well as that from the naturally occurring K^{40} isotope, was

determined. After the gamma ray measurements were made, the hams were dissected and the content of separable lean, separable fat, bone and skin were determined. The separable lean content varied from 6.49 to 11.48 lb. It was found that the net count per minute of K^{40} per ham was highly associated with pounds of separable lean per ham ($r=0.96$). The sample standard deviation from regression was 0.38 lb. Net count per minute of Cs^{137} per ham was found to be associated with pounds of separable lean per ham ($r=0.47$). The sample standard deviation from this regression was about three times as large as in the case of the regression of separable lean on K^{40} counts per minute per ham. Thus it appears that the relationship between Cs^{137} and lean content is not suitable for the purpose of predicting lean content, while the relationship between K^{40} and lean content appears promising.

60. THE RELATIONSHIP OF PERIODIC ELECTRIC SHOCK TREATMENT PRIOR TO SLAUGHTER ON THE CHEMICAL COMPOSITION OF COOKED AND UNCOOKED PORK. P. K. Lewis, Jr., M. C. Heck and C. J. Brown, *University of Arkansas, Fayetteville.*

Twelve market weight hogs were stratified according to weight and sex and allotted at random to two lots of six pigs each. Each lot was treated as described in a previous publication (J. Animal Sci. 18:1477 (1959)). Samples were taken twenty-four hours after slaughter and frozen until chemical composition could be determined. Periodic electric shock treatment prior to slaughter significantly decreased the concentration of glycogen, lactic acid, sugar phosphate, protein and ash; but had no significant effect upon either the moisture or the inorganic phosphate of the uncooked *Psoas major* muscle. This treatment significantly decreased the protein concentration; significantly increased the inorganic phosphate, moisture and ash concentrations; and had no significant effect upon either the glycogen, lactic acid or sugar phosphate concentration of the cooked *Psoas major* muscle. The concentrations of lactic acid and sugar phosphate were significantly decreased but the concentrations of glycogen, inorganic phosphate, protein, moisture and ash of the uncooked *Quadriceps femoris* muscle were not significantly changed by this pre-slaughter treatment. This treatment significantly decreased the lactic acid and protein concentration and significantly increased the inorganic phosphate, moisture and ash concentration of the cooked *Quadriceps femoris* muscle. There was no significant effect of periodic electric shock treatment prior to slaughter upon the chemical composition of either the cooked or uncooked *Longissimus dorsi* muscle.

61. RELATIONSHIP OF GLUCOSE TOLERANCE TO CERTAIN PORK MUSCLE CHARACTERISTICS. J. A. Meyer, R. W. Bray, E. J. Briskey, W. G. Hoekstra and T. Kowalczyk. *University of Wisconsin, Madison.*

Oral feeding of sucrose to swine alters the level of muscle glycogen and affects the physical characteristics of the muscle. Twenty market-weight hogs were given intravenous injections of a 50% solution of glucose and the blood sugar levels were determined at 0, 15, 30 min., 1 and 2 hours. Initial blood sugar levels varied from 60 to 100 mg. percent, rose to above 350 mg. percent and dropped to a low of 40 mg. percent over the two-hour period. The curves could be classified into two main groups, those which indicated high glucose tolerance and those which indicated low tolerance. The data show the relationship between these tolerances and expressible juice in the muscle, muscle pH, muscle color, back fat thickness and the breed of hog. pH of the *Longissimus dorsi* and *Gluteus medius* were taken at 5 min. post mortem and thereafter at 15 min., 30 min., 1, 3, 8 and 24 hours. For half of the hogs pH during the first 8 hours after slaughter was lower than the ultimate pH established after 24 hours of chilling. This group presented a larger variation of muscle color.

62. CARCASS CHARACTERISTICS AND CONSUMER ACCEPTABILITY OF PORK CUTS FROM 160- AND 220-POUND HOGS. A. M. Mullins, D. M. Thrasher, R. F. Boulware, G. L. Robertson and Edmond Guillot, *Louisiana State University, Baton Rouge, and Graugnard Plantation.*

One hundred and twenty-four weanling pigs were fed to slaughter weights of 160 and 220 lb. Carcass characteristics were studied on all hogs and consumer acceptability of ham roasts, ham center slices, loin roasts, loin chops, picnic roasts, Boston butt roasts and sliced bacon was recorded on 80 of the carcasses by 80 family panels. Hogs slaughtered at 220 lb. dressed approximately 3% higher than hogs slaughtered at 160 lb., and the carcasses were approximately 2.5 in. longer. Backfat thickness was about 0.4 in. less and loin eye area per 100 pounds chilled carcass was about 0.6 sq. in. more in the carcasses from lighter hogs. Percent lean cuts was approximately 4% greater and percent trimmed fat was about 5% less from the carcasses of the 160-pound hogs; and, value based on Chicago wholesale prices for pork cuts was approximately $2.00 more per cwt. carcass. "Fatness" in the loin blade roast, picnic and loin chops was criticized twice as often in the heavier hogs. All other cuts were similar in acceptability scores for fatness. The Boston butt was scored as too fat by 58% and 64% of respondents for 160- and 220-pound hogs, respectively. All cuts from both weight groups were rated "liked moderately" or above on acceptability by 85% or more of all respondents. Those cuts rating lowest on general acceptability were criticized consistently as being too fat. This was most pronounced in the loin blade roast, Boston butt, bacon and picnic.

63. ESTIMATING YIELDS OF RETAIL CUTS FROM BEEF CARCASSES. C. E. Murphey, D. K. Hallett, W. E. Tyler and J. C. Pierce, Jr., *U. S. Department of Agriculture, Agricultural Marketing Service.*

Results of several years' studies which involved approximately 450 beef carcasses and over 300 live cattle are summarized. These studies were designed to develop a method for predicting the yield of retail cuts from beef carcasses and live cattle, more specifically, the yield of partially-boneless or boneless retail cuts from the round, loin, rib, and chuck. Using subjective evaluations of exterior and kidney fat, the simple correlation between the estimated and actual yield of bone-in retail cuts was 0.923. Many independent variables were investigated in numerous combinations. The most useful estimating equation was found to be as follows: Percent of boneless retail cuts from round, loin, rib and chuck=51.34—5.784 (fat thickness over rib eye, inches) —.0093 (carcas weight, lb.) —.462 (kidney fat, percent of carcass) +.740 (area of rib eye, sq. in. It was found that some improvement could be made, in most cases, by using a subjective evaluation of finish to adjust the average fatness over the rib eye for variations in the deposition of fat on the various parts of the carcass. The use of these factors is being considered by the Department for use in a revision of grade standards to include identification of variation in yield. This method has been used for evaluating live cattle with considerable success.

64. SENSORY ATTRIBUTES OF PORK DIFFERING IN MARBLING AND FIRMNESS. H. D. Naumann, V. J. Rhodes and J. D. Volk, *University of Missouri, Columbia.*

Loins from 216 pork carcasses were used to determine the influence of firmness of lean and amount of marbling on the shear and organoleptic characteristics of pork chops. A six-member laboratory panel and a 216 member consumer panel evaluated the pork chops. Warner Bratzler shear and loin eye measurements were taken on all loins. Carcasses with thinner backfat yielded loins with less marbling, softer lean and larger loin eye area. Although the laboratory panel was over 85% accurate in

identifying chops of different marbling in a paired comparison, there was no clear cut preference. The consumer panel preferred heavily marbled over sparsely marbled chops in both single stimulus and paired comparison evaluations. Heavily marbled chops had the lowest shear value. Firmness of lean had little effect upon the organoleptic and shear characteristics.

65. RELATIONS OF SENSORY TENDERNESS ANALYSES TO HYDROXYPROLINE CONTENT AND KRAMER SHEARS OF BEEF. F. C. Parrish, Jr., M. E. Bailey and H. D. Naumann, *University of Missouri, Columbia.*

The Troll and Cannan ninhydrin procedure was modified and used to determine the hydroxyproline content of steaks from beef short loin, sirloin tip, top round and bottom round. These results were compared to sensory evaluations of tenderness and with L.E.E. Kramer shear values of these samples. When data of all steak samples (loin and round) were considered, hydroxyproline content was significantly related to tenderness as determined by the sensory panel. Hydroxyproline content and sensory panel data of the short loin and bottom round steaks were significantly related but those from sirloin tip and top round steaks were not. Significant correlations existed between Kramer shear values and sensory tenderness scores and between Kramer shear values and hydroxyproline content when results from all samples were compared. Kramer shear values obtained from short loin and bottom round steaks were significantly related to hydroxyproline content but those obtained from sirloin tip and top round samples were not. Significant differences in tenderness were found between Choice, Standard and Utility grades of round steaks when hydroxyproline content, sensory scores and Kramer shear values were used as indices.

66. FIRMNESS OF BEEF RIB STEAKS AS RELATED TO TENDERNESS AND FAT CONTENT. Dwain H. Pilkington, Lowell E. Walters and J. V. Whiteman, *Oklahoma State University, Stillwater.*

Twenty soft and twenty firm wholesale ribs from the right sides of 650-pound beef carcasses were used in a study of the relationships of ribeye firmness to tenderness and fat content. Subjective and objective measurements were used to evaluate the tenderness, fat content and firmness of two-inch 11th and 12th rib steaks from each wholesale rib. Firmness was measured by a panel and a modified "Precision Penetrometer." The modifications consisted of a single ball and a multiple spike pressure head. Tenderness was measured by the Warner-Bratzler Shear and an experienced taste panel. Marbling scores and the percent ether extract were used to determine the fat content. The steaks were placed in a cooler at 34° F. for 24 hours prior to panel and penetrometer measurements of firmness. Simple correlation coefficients of approximately 0.90 were obtained between the various firmness measurements and between the two measures of fat content. The analyses of variance indicated that firmness was related to fat content and tenderness. Positive simple correlations ($r \sim 0.20$) were found between firmness and tenderness. Fat content was found to be positively associated with firmness and tenderness ($r \sim 0.70$ and 0.50, respectively). Partial correlation coefficients between firmness and the Warner-Bratzler shear values and taste panel scores, with fat held constant, were of the order of —.35 and —.15, respectively. These data suggest that, with fat content held constant, the softer rib steaks tended to be more tender than the firmer rib steaks.

67. A PHOTOMETRIC METHOD OF DETERMINED RANCIDITY IN PORK FAT. C. B. Ramsey, James D. Kemp and R. B. Grainger, *University of Kentucky, Lexington.*

A simple, fast colorimetric procedure was developed for determining lard rancidity. The procedure is as follows: Add 300 lambda of lard and 5 ml. of

isopropanol to 10 ml. of 0.8019 M KOH-isopropanol solution and shake. Heat in a 70° C. water bath for 6 minutes. Read the optical density at 385 millimicrons on a colorimeter using the heated KOH-isopropanol solution as a reagent blank. The optical density at 385 millimicrons is termed the Ranco value. The following highly significant correlations were found between Ranco values and other rancidity tests: peroxide numbers, $r = 0.918 \pm .120$; iodine numbers, $r = -.996 \pm .026$; TBA values, $r = 0.934 \pm .108$; and colony counts of Ramsey's microbiological method, $r = 0.970 \pm .073$. Ranco values increased with increasing concentrations of heptaldehyde from 0.7×10^{-4} to 14×10^{-4} M. Since Ranco values increased with lard oxidation, it was concluded that carbonyl compounds are responsible for the Ranco test.

68. CARCASS GRADE AND DRESSING PERCENT OF CATTLE FED DIFFERENT LEVELS OF PROTEIN IN HIGH-GRAIN RATIONS. C. E. Summers, Wise Burroughs, E. A. Kline and Walter Woods, *Iowa State University, Ames.*

Three experiments involving 276 head of yearling steers and six different levels of ration protein (8.5, 9.0, 9.5, 10.0, 10.5 and 13.5%) were conducted to determine the effect of protein level upon federal carcass grade and dressing percent. The rations fed daily per steer consisted of 1.5–3.0 lb. of hay, 0.5–2.5 lb. of protein supplement with a full feed of ground ear corn or ground shelled corn or a combination of both. Both carcass grade and dressing percent were increased with each succeeding higher level of ration protein up to approximately 11.5%. Federal carcass grade was increased 0.26 of a grade when the level of ration protein was increased from 8.5% to approximately 11.5%. Dressing percent was increased from 59.3 to 61.3%. The area of the *Longissimus dorsi* muscle and the thickness of fat cover over the twelfth rib section, when measured on cattle fed 9.0, 9.5 and 10.0% ration protein proximated the observations on carcass grade and dressing percent. Fat thickness increased 0.012 in. per 100-lb. body weight and ribeye area increased 0.015 sq. in. per 100-lb. body weight when the ration protein was increased from 9.0 to 10.0%. Feedlot performance was optimum when the ration contained as little as 9.5% protein and was not improved by higher levels.

69. A MYOMETRIC STUDY OF THE LONGISSIMUS DORSI OF THE BOVINE. L. A. Swanson, E. A. Kline and L. N. Hazel, *Iowa State University, Ames.*

The variation in the size of the muscle fibers in the *Longissimus dorsi* muscle of the bovine was studied in samples obtained at five different anatomical positions in the rib and shortloin from both the right and left sides. Five fixed locations from each of the ten positions were then sampled to determine the area of individual muscle fibers and the number of muscle fibers in a 0.04 square millimeter area. The data were treated statistically by use of analysis of variance. The size of the fibers was smallest in the region of the 12th rib and increased in size in both directions from this point. The smallest fibers in any location were in the ventral aspect of the muscle where part of its insertion was located. No significant differences were noted between the two sides.

70. THE RELATIONSHIP OF FIBER DIAMETER TO TENDERNESS AND MEATINESS AS INFLUENCED BY BOVINE AGE. H. J. Tuma, J. H. Venable, P. R. Wuthier and R. L. Henrickson, *Oklahoma State University, Stillwater.*

The *Longissimus dorsi* and *semitendinosus* muscles from both sides of 33 animals of five different age groups were studied. Muscle samples from the left side were taken at 48 hr. and those from the right side 14 days after slaughter. Samples for fiber diameter were taken from the *L. dorsi* at the 13th rib. A portion of three one-inch

core samples corresponding to those taken for the Warner-Bratzler shear values were teased in a micro-blender. A single core was taken from the center of the *semitendinosus* for the fiber diameter measurement. Fifty teased fibers from each core were measured. The mean fiber diameters for both *L. dorsi* muscles were 53.9, 62.1, 65.1, 69.4 and 71.4 microns, respectively, for the 6-, 18-, 24-, 42- and 90-month-old age groups. In the same age sequence the means for both semitendinosus muscles were 52.5, 63.2, 65.7, 65.7 and 64.8 microns. The gross correlations between fiber diameter and the Warner-Bratzler shear values for the *L. dorsi* aged 48 hrs. and 14 days were 0.43 and 0.63; and for the semitendinosus aged 48 hrs. and 14 days, 0.42 and 0.47 (requirement for 1% probability, r, 0.443). With the age effect removed, the r values were 0.465 and 0.038 for the *L. dorsi* and 0.164 and —.217 for the semitendinosus (0.367 required for 5% probability). The gross correlation between fiber diameter and loin eye area was 0.56; with age effect removed the correlation decreased to —.104. Aging had little effect on the fiber diameter in both muscles. In the *L. dorsi*, there was a significant "position effect". The mean fiber diameters for the dorsal, middle and lateral cores were 68.10, 65.09 and 62.24 microns, respectively.

71. CHARACTERISTICS OF THE CARCASS AND COMPOSITION OF MUSCLE OF MARKET HOGS AS INFLUENCED BY AGE AT SLAUGHTER. B. D. VanStavern, L. E. Kunkle, W. H. Bruner and R. M. Johnson, Jr., *Ohio State University, Columbus.*

Eighty-seven hogs from the Ohio Swine Evaluation Station were studied for the influence of age at market weight on carcass characteristics and muscle composition. The animals ranged from 129 to 183 days of age, mean of 154 days. Percentage primal cuts, percentage lean cuts, area of loin eye, backfat thickness and percentage fat for lard were used to describe carcass characteristics. All percentages were based upon a chilled carcass weight. No statistical significant difference could be shown between any of these carcass characteristics and age at slaughter weight. A section of the *Longissimus dorsi* muscle taken at the 11–13th rib was analyzed for percentage moisture, ether extract, and protein. Iodine number of the intramuscular fat, calories per 100 gm. of fresh tissue, free fatty acid value, and pH of the muscle tissue were also determined. No significant relationship could be shown between any of the above factors of muscle composition and age at slaughter. It is concluded that the carcasses from young, rapid gaining hogs are not significantly different from the carcasses produced by older, slower gaining hogs.

72. EFFECTS OF PASTURE FORAGES, INCLUDING WILD ONIONS AND WEEDS, ON FLAVOR OF BEEF. W. Y. Varney and James D. Kemp, *University of Kentucky, Lexington.*

In April of 1957, three groups of eight steers ranging in weight from 608 to 734 lb. were placed on the following pasture mixtures: 1, Brome grass and Ladino clover; 2, Bluegrass and white clover; and 3, Bluegrass and Birdsfoot trefoil. In August a fourth group of eight similar steers. was placed on a predominantly Ragweed (Ambrosia elatior) pasture. They grazed 60 days and then were fed chopped Ragweed for 10 days in dry-lot. All cattle were slaughtered in October. Palatability tests revealed no significant differences in flavor, juiciness or tenderness among any of the groups. In a separate part of the experiment, twelve Hereford steers were placed on a mixed grass pasture that was heavily infested with wild onions (Allium sp.). After 3 weeks one steer was removed and slaughtered. The meat contained a very undesirable onion flavor. After 4 weeks the remaining steers were removed from the pasture and two were slaughtered the day of removal. The others were placed on dry feed and water and two were slaughtered on each of the second, fourth, and sixth days after removal from the pasture. Beef from the steers slaughtered the day of removal had a marked

onion flavor; after 2 days, slight onion flavor; and after 4 days, no detectable onion flavor. The remaining three steers were fed onion tops for 4 days and slaughtered on the zero, second and fourth days. Results were similar to the previous test.

73. FACTORS AFFECTING CARCASS CHARACTERISTICS OF HEAVY, GRASS AND MILK-FED CALVES. W. Y. Varney, J. D. Kemp and N. W. Bradley, *University of Kentucky, Lexington.*

Twenty-three grade Hereford and 24 Red Poll heifers were bred in 1956 to calve during the winter and spring of 1957. One-half of each breed was bred to one of two purebred Herefords, one of which was visually judged to be superior. The calves were divided so that as nearly as possible an equal number of each bull's calves was creep-fed a grain mixture during the entire grazing season. All calves suckled their dams throughout their lives on pasture and were slaughtered in October. After some culling the same cows were bred for the 1958 calf crop and again for the 1959 calf crop. However, a different pair of purebred Hereford bulls, one a high gainer and the other a low gainer as determined by a performance test, were used in each of these years. Calves were treated similar to those of 1957. It was concluded that the Red Poll × Hereford calves obtained higher carcass grades, had greater carcass yields, had more marbling and attained a greater carcass weight per day of age than Hereford calves. Hereford calves had a larger ribeye area per 100-lb. of carcass than Red Poll × Hereford calves. Creep feeding was advantageous in only one year out of three, apparently being useful only during unfavorable grazing seasons. The performance of purebred Hereford bulls on test for rate of gain was not reflected in carcass traits of the offspring.

74. THE ESTIMATION OF LOIN EYE AREA BY HIGH FREQUENCY SOUND. S. E. Zobrisky, Wm. G. Moody, Wm. Day and H. D. Naumann, *University of Missouri, Columbia.*

High frequency sound (Branson Sonoray, Model 5) was employed to estimate the area of the *Longissimus dorsi* muscle of 69 live hogs. The hogs were measured at the 10–11th rib on both sides of the mid-line. Subsequently the hogs were slaughtered and a tracing made of the loin eye area on the right and left side behind the 10th rib. Additional tracings of the loin eye area were made behind the second and last rib on the right side. The correlation between the tracings of the 10th rib loin eye area of the right and left side was 0.95. The correlation between the high frequency sound estimates of the same two variables was 0.91. Tenth rib loin eye tracing and high frequency sound estimates of the 10th rib loin eye area for the right and left side were also correlated 0.84 and 0.81, respectively. The loin eye areas at the second and last rib were correlated with the 10th rib, 0.75 and 0.93, respectively, for the right side, and 0.78 and 0.92 for the left side. Likewise, the high frequency sound loin eye area estimates at the 10th rib were correlated with the second and last rib loin eye area, 0.61 and 0.78, respectively, for the right side, and 0.62 and 0.77 for the left side. Length and width measurements of the 10th rib loin eye cut surface were correlated ($P<0.001$) with the area tracing and also high frequency sound estimates of the 10th rib loin eye area.

75. THE HAM EQUIVALENT AS AN INDEX OF CARCASS VALUE. S. E. Zobrisky, Wm. Moody and H. D. Naumann, *University of Missouri, Columbia.*

The ham equivalent incorporates the wholesale cut value and yield of each carcass cut into a single index which reflects carcass merit. The ham equivalent index of 133 barrows was significantly correlated ($P<0.01$) with conventional indices of carcass meatiness. The correlation between the ham equivalent and yield of four lean cuts

was, 0.82; yield of loin, 0.56; yield of fat, —.47; loin eye area at tenth rib and last rib, 0.60 and 0.65, respectively. Carcass length was not significantly correlated with the ham equivalent, loin eye areas or yield of four lean cuts. The results of this study suggest a method of evaluating carcasses on the basis of the value of each wholesale cut as well as the yield of preferred cuts.

76. LIVE HOG AND CARCASS RELATIONSHIPS BETWEEN BOAR, BARROW AND GILT LITTERMATES. S. E. Zobrisky, L. F. Tribble, Wm. G. Moody and H. D. Naumann, *University of Missouri, Columbia.*

Live hog and carcass data were analyzed from two groups of hogs. Group I included a boar, barrow and gilt from 33 litters. Group II included 112 lots composed of three littermates (one barrow and two boars) and one non-related boar. Loin eye area at the second and tenth rib, separable lean and bone of the ham were correlated ($P<0.01$) between the boar and barrow, boar and gilt and barrow and gilt littermates. The percentage ham fat and carcass fat were not significantly associated. Backfat measurements from the boars and gilts and also from the barrows and gilts were correlated ($P<0.01$); however, no significant relationship was found between backfat measurements of the boars and barrows. The percentage four lean cuts from the boars and barrows was correlated ($P<0.05$). The increase in percentage four lean cuts per unit increase of loin eye was not as large as the increase in percentage fat per unit increase of backfat thickness. For each unit increase of backfat thickness the percent of trim fat was twice as great for barrows as for boars and gilts. In Group II live hog backfat probes from the littermate barrow and boars and also from littermate boars were correlated ($P<0.01$). Backfat probes from the three siblings were not significantly correlated with the backfat probes from the non-related boar.

77.

78. RATE OF OVULATION AND IMPLANTION IN SWINE AS AFFECTED BY DIETARY PROTEIN. C. R. Adams, D. E. Becker, S. W. Terrill, H. W. Norton and A. H. Jensen, *University of Illinois, Urbana.*

Sixty gilts were allotted at random to six treatment groups which received, (1) a "protein-free" diet, (2) a corn diet, (3) a 16% corn-soybean meal diet, (4) a 32% corn-soybean meal diet, (5) a 15% corn-sesame meal diet, and (6) a 15% corn-sesame meal diet plus 0.25% supplemental L-lysine hydrochloride. The gilts were bred at the third observed heat period, and at the 25th day of gestation they were slaughtered. Number of corpora lutea, number and weight of embryos, the ovary, pituitary and thyroid weights and the gonadotrophic and thyrotrophic hormone concentration of the pituitaries were measured. The results showed that gilts on a protein-free diet failed to cycle normally or conceive. Ovulation rate and number of embryos present were greatest in the lots receiving either the 32% protien diet or the 15% corn-sesame meal diet plus lysine. The lots receiving the 32% protein diet, the 15% corn-sesame meal diet with and without supplemental lysine had the greatest weight gains and feed efficiency. Whole and anterior pituitary weights were lowest with the gilts that received the corn diet. Embryo, ovary, and thyroid weights did not differ. Thyrotrophic hormone concentration of the pituitaries was lowest in gilts from the lot receiving the "protein-free" diet but greatest with gilts that received the 15% corn-sesame meal diet. The concentration of gonadotrophin was lower in gilts that received the "protein-free" diet, 16% corn-soybean diet and the 15% corn-sesame meal diet than in those on the remaining treatments.

79. DRIED TOMATO PULP AS A FEED FOR STEERS AND LAMBS. C. B. Ammerman, L. R. Arrington, P. E. Loggins, J. T. McCall and G. K. Davis, *Florida Agricultural Experiment Station, Gainesville.*

Dehydrated tomato pulp, prepared from cull tomatoes, was used in a nutritional evaluation of the product. The proximate analysis of the pulp showed it to be lower in ether extract and crude fiber than values reported for tomato pomace. A conventional digestion trial was conducted with steers in which the tomato pulp was evaluated when fed alone and in combination with Alyce clover hay. The percent total digestible nutrients of the tomato pulp was 60 when determined by difference and 57 when the pulp was fed alone. A nitrogen balance trial was conducted with lambs in which the protein of tomato pulp was compared with that of soybean oil meal. Approximately 55% of the total protein was supplied by the pulp or soybean oil meal. Apparent digestibility and estimated biological values of the nitrogen in percent were 51 and 57 for the tomato pulp and 69 and 64 for the soybean oil meal.

80. EFFECT OF LYSINE SUPPLEMENTATION OF HIGH-GOSSYPOL COTTONSEED OIL MEAL RATIONS FOR BABY PIGS. A. Aguirre, H. D. Wallace and G. E. Combs, *University of Florida, Gainesville.*

Sixty two-week-old pigs were individually fed in two experiments to study the effect of L-lysine supplements to a commercial grade cottonseed meal containing 42.3% protein, 0.058% free gossypol, and 0.79% total gossypol. Performance data were summarized at eight weeks of age. For experiment 1, using *ad libitum* feeding, the respective dietary treatments, daily gains, and feed efficiencies were: (1) soybean meal (SM) control—1.02, 1.92; (2) cottonseed meal (CM) control—0.31, 2.71; (3) CM + 0.1% lysine—0.46, 2.54; (4) CM + 0.2% lysine—0.60, 2.43; and (5) CM + 0.4% lysine—0.66, 2.20. In experiment II feeding was restricted to equalized levels. Treatments, average daily gains, and feed conversion values were: (1) SM control—0.51, 2.07; (2) SM + gossypol acetate—0.48, 2.22; (3) CM control—0.29, 3.02; (4) CM + 0.4% lysine—0.38, 2.69; and (5) CM + 0.8% lysine—0.40, 2.64. The soybean meal control treatments produced highly significant ($P<.01$) better rate of gain and feed efficiency than any of the supplemented or non-supplemented cottonseed meal treatments. Observations indicated that lysine improved the nutritive value of cottonseed meal and provided some degree of resistance to gossypol poisoning of baby pigs as shown by performance and subsequent mortality. Gossypol acetate added to the soybean meal control diet in the second experiment did not lower significantly the rate of gain or feed efficiency.

81. EFFECT OF AMINO ACID ADDITIONS TO A FORTIFIED CASEIN-LACTOSE DIET FOR EARLY-WEANED PIGS. J. P. Baker, D. E. Becker, A. H. Jensen and S. W. Terrill, *University of Illinois, Urbana.*

Three experiments involving 84 pigs weaned to dry diets at approximately 18 days of age were conducted to determine the effect of amino acid additions to fortified casein-lactose diets imbalanced with excess amounts of casein or of amino acids. In Trial I the treatments were as follows: (1) 25% protein, (2) 50% protein, (3) 75% protein, (4) as 1 + 1% arginine·HCl, (5) as 2 + 1% arginine·HCl, and (6) as 3 + 1% arginine·HCl. The average 28-day gains and gain:feed ratios were as follows: (1) 14.1, 0.60; (2) 12.0, 0.62; (3) 6.5, 0.52; (4) 12.3, 0.58; (5) 10.9, 0.62; and (6) 7.4, 0.56. Analysis of the data revealed a significant protein effect but no arginine effect. In Trials II and III a fortified casein-lactose diet (20% protein) was used with methionine to imbalance the diet. Additions of arginine and of arginine plus glycine were studied for their effectiveness in alleviating the imbalance. The treatments in both trials were as follows: (1) basal diet, (2) as 1 + 2.6% methionine, (3) as 1 + 3.6% arginine·HCl, (4) as 2 + 3.6% arginine·HCl, (5) as 3 + 1.3% glycine, and

(6) as 4 + 1.3% glycine. The average 21-day gains and gain:feed ratios were as follows: Trial II (1) 6.13, 0.50; (2) 6.27, 0.52; (3) 9.60, 0.82; (4) 2.23, 0.35; (5) 10.1, 0.69; and (6) 1.83, 0.29. Trial III (1) 9.80, 0.48; (2) 5.53, 0.39; (3) 1.97, 0.47; (4) 3.70, 0.36; (5) 9.07, 0.53; and (6) 2.37, 0.27. There was not a clear-cut effect from methionine in Trial II but a marked depression from methionine plus arginine with no effect from glycine. Methionine depressed gains in Trial III and this effect was enhanced by arginine and glycine.

82. VIRGINIAMYCIN, A NEW ANTIBIOTIC, FOR GROWING SWINE. C. E. Barnhart, J. C. Robertson and H. W. Miller, *University of Kentucky, Lexington.*

Four trials involving 195 weanling pigs were conducted to study the value of virginiamycin in growing swine rations. A corn-soybean meal basal ration was fed. In trials 1, 2 and 3, two lots of five pigs each were fed each ration on concrete. In trial 4 five pigs were individually fed each ration in wire floored crates. In trials 1, 3 and 4 pigs were fed to a weight of 100 lb. and in trial 2 to a final weight of 200 lb. The additives per ton of ration for trials 1 and 2 were: (1) none, (2) 40 gm. Aureomycin, (3) 20 gm. virginiamycin, (4) 40 gm. virginiamycin. The additives per ton of ration for trials 3 and 4 were: (1) none, (2) 10 gm. virginiamycin, (3) 20 gm. virginiamycin, (4) 40 gm. virginiamycin, (5) 80 gm. virginiamycin, (6) 10 gm. Aureomycin, (7) 20 gm. Aureomycin, (8) virginiamycin mycelium 10 gm. activity (not fed in trial 4). The average daily gain (lb.) and feed per lb. of gain for trial 1 were: (1) 1.17, 3.19; (2) 1.26, 3.12; (3) 1.32, 2.92; (4) 1.48, 2.87. For trial 2 they were: (1) 1.45, 3.95; (2) 1.50, 3.71; (3) 1.60, 3.58; (4) 1.67, 3.44. For trial 3 they were: (1) 1.24, 3.06; (2) 1.21, 2.90; (3) 1.37, 2.72; (4) 1.30, 2.87; (5) 1.39, 2.73; (6) 1.28, 3.10; (7) 1.21, 3.13; (8) 1.32, 2.78. For trial 4 they were: (1) 1.14, 2.63; (2) 1.26, 2.46; (3) 1.14, 2.47; (4) 1.31, 2.43; (5) 1.29, 2.52; (6) 1.15, 2.56; (7) 1.22, 2.43.

83. AMINO ACID COMPOSITION OF RUMEN FLUID AND RUMEN MICRO-ORGANISMS. J. S. Baumstark, R. A. Bloomfield, G. B. Garner and M. E. Muhrer, *University of Missouri, Columbia.*

Four amylolytic streptococci were isolated from the rumen of a sheep on a roughage ration. These organisms appeared to conform to the characteristics of *Streptococcus bovis.* Their amino acid requirements appeared to be simple. Two of the organisms did and two did not exhibit a requirement for glutamic acid when this amino acid was omitted from the medium. With the exception of glutamic acid the organisms required no single amino acid. However, three of the organisms failed to grow when the acidic amino acids were eliminated. One organism failed to grow when the basic amino acids were omitted and two organisms failed to grow in the absence of the aromatic amino acids. The amino acid composition of rumen fluid and of dried preparations of the isolated organisms was determined using a quantitative ion exchange chromatographic method. Tryptophane was not determined. The amino acid content of rumen fluid agreed very well with the composition of the streptococci. Organisms were isolated for analysis from sheep on both practical and synthetic type rations. The amino acid content of the rumen fluid and of the isolated bacterial protein was similar to that of casein. The rumen fluid and bacteria appear to contain the essential amino acids in the relative proportions that should satisfy the animal's requirement.

84. INFLUENCE OF DIETARY CALCIUM AND ZINC ON CALCIUM-45, PHOSPHORUS-32 AND ZINC-65 METABOLISM IN SWINE. R. K. Berry, M. C. Bell, R. B. Grainger and R. G. Buescher, *University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory and University of Kentucky, Lexington.*

Thirty-two weanling barrows (av. weight 46 lb.) were allotted into four lots and fed the following diets: basal, basal + 71 ppm zinc, basal + 0.6% calcium and

basal + 71 ppm zinc + 0.6% calcium. The corn-soybean oil meal basal contained 0.59% calcium and 29 ppm zinc. At the end of a 28-day growth study, 4 pigs/lot were placed in balance crates and dosed orally with Ca^{45}, P^{32} and Zn^{65} for a 6-day study of chemical and radiochemical mineral metabolism. Dietary calcium or zinc had no effect on gains, feed consumption or feed conversion; and, no parakeratosis was observed. Stable plasma calcium, stable blood phosphorus, stable or radioactive phosphorus balance and Ca^{45} or Zn^{65} excretion were not significantly affected by dietary treatment. Excess calcium resulted in a significant ($P<0.01$) increase in stable calcium retention. Calcium decreased ($P<0.01$) chemical and radiochemical urinary phosphorus output, but had no effect on fecal phosphorus excretion. Ca^{45} plasma and blood levels were depressed by dietary calcium ($P<0.01$). Calcium decreased blood, plasma ($P<0.01$) and total tissue ($P<0.05$) Zn^{65} levels, when added to a low zinc ration; however, calcium increased blood and total tissue ($P<0.05$) activity when supplemented to high zinc ration. Calcium depressed plasma P^{32} activity ($P<0.05$). Zinc increased blood P^{32} levels ($P<0.05$). Dietary zinc decreased ($P<0.01$) blood, plasma and tissue retention of Zn^{65} in the lung, heart, spleen, kidney, pancreas, wall of small intestine, muscle, and skin.

85. KINETICS OF UREA METABOLISM IN SHEEP. R. A. Bloomfield, G. B. Garner and M. E. Muhrer, *University of Missouri, Columbia.*

Rumen samples were removed from a sheep via a fistula and placed in an incubation flask. Serial samples were taken from these aliquots after incubation. This allowed the rate of hydrolysis of the fed urea and the uptake of the resulting ammonia by the rumen microorganisms to be studied. The urea of a synthetic diet was hydrolyzed at the rate of 80 mg. urea nitrogen (UN) per hour per 100 ml. of rumen fluid (RF). The resulting ammonia was taken up by the microorganisms at the rate of 20 mg. ammonia nitrogen (AN) per hour per 100 ml. RF. The uptake of AN proceeded at a constant rate of $30.54 \pm 9.2\%$ of AN present over a wide range of ammonia concentrations. After 6 hours, nitrogen was returning to the rumen at the rate of 1.26 mg.N/hour/100 ml. RF and being utilized at the above rate. The disappearance of AN from the rumen could not be accounted for by the rate of uptake of AN by the microorganisms. An animal was anesthesized and the portal vein exposed. After 60 min. portal AN had risen to 1.62 mg. AN/100 ml. blood with no increase in jugular AN. The above quantitative data support the hypothesis that urea is hydrolyzed more rapidly (4 times) than the corresponding uptake of AN. The excess UN is absorbed out of the rumen and lost to protein synthesis by the microorganisms, but not all is lost as some is returned to the rumen.

86. AN EVALUATION OF CALORIE-PROTEIN RATIOS FOR GROWING-FINISHING SWINE. D. E. Boenker, L. F. Tribble and W. H. Pfander, *University of Missouri, Columbia.*

180 Duroc and Hampshire weanling pigs were fed corn-soybean oil meal rations containing three levels of protein 13, 16 and 19% (reduced to 10, 13 and 16% after pigs reached 125 lb.) and three levels of metabolizable energy, approximately 1266, 1430, 1592 Calories per pound (Titus). Identical rations were fed during the winter and summer. Ground corn cobs and stabilized animal grease were used to adjust the energy level. The Calorie-protein ratio had no influence on growth, feed efficiency or ration digestibility. From weaning to 125 lb., gains and feed efficiency increased ($P=.05$ and $P=.01$ respectively) as the level of energy in the ration increased. Protein level had little influence on gains or feed efficiency. Pigs from 125 to 200 lb. gained faster as the level of energy in the ration increased ($P=.05$). Pigs fed 10% protein gained slower ($P=.01$) and were less efficient ($P=.01$) than those fed 13 and 16% rations. Feed efficiency increased linearly ($P=.01$) with increasing levels of energy in the ration.

Widening of the Calorie-protein ratio at each protein level increased the deposition of backfat. There was a linear (P=.01) response to the energy and protein level on the backfat thickness, which increased with each increase in energy, or decrease in protein level of the ration. Ether extract digestibility increased with the addition of fat to the ration. The addition of fiber to the ration decreased the digestibility of the ration nutrients.

87. FISSION PRODUCTS IN NEVADA RANGE CATTLE. V. R. Bohman, G. R. Farmer, M. A. Wade and M. A. Van Dilla, *University of Nevada, Reno; Atomic Energy Commission; Las Vegas, Nev.; and Los Alamos Scientific Laboratory, Los Alamos, New Mexico.*

Bovine tissues from cattle maintained in three areas in Nevada have been sampled for various fission and related products. The experimental herds have been located on the Nevada Test Side, Delamar Valley, located 75 miles east of the Test Site; and Knoll Creek, located 330 miles north of the Test Site and immediately south of the Idaho border. Twice yearly, cattle stratified according to age, were sacrificed. Bone Sr^{90} levels were similar to levels found in other cattle in the United States. Total Sr was lower in cattle from northern Nevada. Younger cattle had higher levels of Sr^{90} but lower levels of total Sr. The femur was higher in both total Sr and Sr^{90} than the rib. Sr^{90} concentration was much greater in the rumen contents and feces than in body tissues, demonstrating body selectivity for this nuclide. Milk Sr^{90} was low. Cs^{137} content of muscle and liver was similar to commercial beef in various parts of the country. I^{131} levels in the thyroid have been low except immediately after test shots. Zn^{65}, a non-fission product, has shown up in animal tissues. Other short-lived isotopes apparently are poorly absorbed by the animal. No gross or histo-pathology related to fallout has been observed.

88. ABSORPTION AND SECRETION OF NUTRIENTS IN DIFFERENT SECTIONS OF THE ALIMENTARY TRACT OF THE SHEEP. D. W. Bolin, W. E. Dinusson, D. O. Erickson and M. L. Buchanan, *North Dakota Agricultural College, Fargo.*

Nutrient absorption from different sections of the alimentary tract was determined. Results were obtained with the use of pelleted forage containing uniform amounts of chromic oxide. Six sheep were fed daily 1300 gm. of pelleted forage. At the end of a three-week feeding period, the sheep were sacrificed and various sections of the alimentary tract tied off, namely, rumen, reticulum, omasum, abomasum, duodenum, jejunum, ileum (anterior) ileum (posterior) caecum, large colon, small colon, and rectum. The contents of each section were then removed and analyzed for dry matter, nitrogen, water, water-insoluble nitrogen, ash, and chromic oxide. The amount of digestion, absorption, secretion, reabsorption and physical separation was estimated for the 1300-gram daily intake of feed for each section. Very little absorption of protein and carbohydrates occurred after passage through the posterior ileum. Mineral matter appeared to be absorbed in appreciable amounts in the large and small colon.

89. PROTEOLYTIC ACTIVITY OF RUMEN FLUID. Raymond Borchers, *Univerisity of Nebraska, Lincoln.*

Rumen fluid, obtained from a fistulated steer by squeezing the rumen ingesta through cheese cloth, was used for a study of proteolytic activity. Casein, 5% at pH 6.5, was used chiefly as the substrate. Thymol was added to prevent destruction of proteolytic products. Ten ml. casein substrate, 90 ml. rumen fluid, and 50 mg. thymol were incubated at 40° C. with bubbling carbon dioxide. Proteolytic products were

determined on trichloracetic acid filtrates by the alkaline copper salt (Anal. Chem. 31:1179, 1959), Kjeldahl, tyrosine (Folin-Ciocalteu phenol reagent), and ninhydrin methods. The activities observed in millimoles of product per 100 ml. rumen fluid per hour were according to above order of method 0.5 millimole amino acid, 4 millimole nitrogen, 0.1 millimole tyrosine, and 0.3 millimole amino acid, respectively. The pH optimum was approximately 6.5. Some 80–90% of the proteolytic activity was associated with the sediment obtained by high speed centrifugation. Attempts to obtain a cell-free preparation have been successful. The proteolytic activity was gradually lost during storage. When gelatin or dried milk were incubated with rumen fluid, proteolytic activities (products) approximately equal to those obtained with casein were observed; soybean oil meal (heated or raw), peanut oil meal, linseed oil meal, glycinin, and hemoglobin showed some activity; while alfalfa, wheat, corn, oats, blue grass, and zein gave little or no evidence of proteolysis.

90. EFFECTS OF SHADE AND ESTRADIOL-TESTOSTERONE IMPLANT ON THE PERFORMANCE AND CARCASS CHARACTERISTICS OF SUMMER-FATTENED HEIFERS. F. W. Boren, E. F. Smith, B. A. Koch, D. Richardson and S. Wearden, *Kansas State University, Manhattan.*

Fattening trials were conducted for a period of 140 days during June–October in 1957–58–59 with 600-pound yearling Hereford heifers. Shades were constructed of sheet-metal on frames mounted to posts and provided 32 sq. ft. of shade per head. The shades were 10–12 feet high. The implants contained 20 mg. estradiol and 100 mg. testosterone. The experiment was so designed that during each year implanted and non-implanted heifers were fed in shaded and non-shaded lots. Cracked sorghum grain fed at maximum consumption, 1 lb. soybean meal, and 5 lb. alfalfa hay constituted the daily ration. Shade, irrespective of implant, and implant, irrespective of shade, produced a significant ($P<0.05$) increase in average daily gain. Both shade and implant were responsible for increased feed efficiency. Shade had no significant effect upon carcass grade, average fat thickness at the 12th rib, or size of ribeye. Carcasses from implanted heifers graded significantly lower ($P<0.05$) and had a significantly ($P<0.01$) greater area of ribeye muscle. Although implanted heifers averaged 25 lb. heavier at market than non-implanted heifers, an adjustment of all the heifers to a common weight and using covariance analysis revealed a highly significant ($P<0.01$) difference in size of ribeye due to implant. The between-year difference in average daily gains of the shaded and/or implanted heifers was highly significant ($P<0.01$), being due apparently to considerable difference in summer weather conditions.

91. DIGESTIBLE ENERGY AND DIGESTIBLE PROTEIN STUDIES ON VARIOUS LEVELS OF CONCENTRATES IN PELLETED RATIONS FOR FATTENING LAMBS. B. E. Brent, D. Richardson, W. S. Tsien and C. S. Menzies, *Kansas State University, Manhattan.*

Digestible energy and dry matter, protein digestion coefficients and nitrogen retention were determined with nine wether lambs averaging 66 lb. Pelleted rations were fed containing the following ratios of alfalfa hay to sorghum grain: 90–10, 80–20, 70–30, 60–40, 50–50, and 40–60. Seven-day collection periods were used with preliminary periods of 9 days. Highly significant differences ($P<.01$) in digestible energy were found on the various rations, digestible energy increasing in an almost perfect linear relationship with increasing concentrates in the ration. Correlations of 0.867 to 0.999 were found between digestible dry matter and digestible energy. Protein digestion coefficients increased from 65.7% on the 90–10 ration to 72.0% on the 70–30 ration, and then leveled off to 73.0% on the 40–60 ration. There was no significant difference between the 90–10 and 80–20 rations, or between the 70–30,

60–40, 50–50, or 40–60 rations, but a highly significant difference between the 80–20 and 70–30 rations. Percent of nitrogen retained showed a highly significant ($P<.01$) differences due to rations. Mean retention percentages increased from —.2 on the 90–10 ration to 27.1 on the 50–50 ration, and then decreased to 23.5 on the 40–60 ration. Wide variations between lambs in percentage nitrogen retained indicated that nitrogen retention might not be an accurate measurement of the value of a ration. Average gain per lamb was 41 lb. during the four-month trial.

92. EFFECT OF TANKAGE IN GROWING SWINE RATIONS ON GROWTH AND CERTAIN CARCASS CHARACTERISTICS. C. C. Brooks, H. R. Thomas and R. F. Kelley, *Virginia Polytechnic Institute, Blacksburg.*

Two experiments, two trials in each, were conducted to investigate the effect tankage in the ration of growing swine. Tankage from a different Virginia packing plant was used in each of the four trials. Each trial included three lots of seven pigs, which were fed as follows: Lot 1—corn-soybean oil meal, Lot 2—corn-soybean oil meal and tankage (17% of the total protein from tankage) and Lot 3—corn-tankage. A fourth lot in each of the last two trials received corn and a trio mix consisting of 50% soybean oil meal, 25% tankage, and 25% alfalfa meal. There were no apparent differences that could be attributed to tankage source and no difference between trials in either experiment. Pigs receiving soybean oil meal in the ration made significantly faster gains than those receiving corn-tankage. The mean daily gains for Lots 1, 2 and 3 in all four trials were 1.58, 1.61, and 1.29., respectively. Loin eye areas were significantly larger in the pigs from lots receiving tankage. The means for the four trials being 3.79, 4.23, and 4.09 sq. in. for Lots 1, 2, and 3, respectively. There were no differences in backfat, carcass length or yield between the three lots. There was no significant difference between Lots 2 and 4 of the second experiment in any of the measured variables.

93. EFFECT OF FEEDING DRIED POTATO PULP AT TWO LEVELS OF PROTEIN, INCLUDING UREA, TO HEREFORD BULLS. H. H. Brugman and H. C. Dickey, *University of Maine, Orono.*

Dried potato pulp is a high energy and low protein feed. It contains 79% TDN and 5% crude protein. In previous feeding trials using 9% protein mix, average daily gains were about 2 lb. Rations with a narrower nutritive ratio containing 10% and 14% protein were fed to two lots of beef bulls for 140 days. Starting age of the bulls was 355 days. The rations contained ½% and 1% urea, respectively, and 3000 units of vitamin A per pound. Both rations were very palatable. Bulls receiving 10% protein mix gained an average of 2.74 lb. per day at a feed cost of $0.146 per pound. Feed conversion was 529 lb. of dried potato pulp mix and 153 lb. of hay per 100-lb. gain. Bulls receiving 14% protein mix gained an average of 3.18 lb. per day at a feed cost of $0.164 per lb. of gain. Feed conversion was 550 lb. dried potato pulp mix and 123 lb. of hay. This lot reached comparative weights 20% faster on less feed. Live grades were the same in each lot. There was no ill effect from the urea in the rations.

94. EFFECT OF EXCESSIVE CALCIUM ON SELENIUM-75 IN SWINE. R. G. Buescher, M. C. Bell and R. K. Berry, *University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory, Knoxville.*

Corn-soybean meal rations with excessive calcium, 1.2 and 2.4%, were fed. The 2.4% decreased growth rate, feed consumption and feed efficiency. Eighteen barrows were orally dosed with Se^{75}. Blood, plasma, urine and feces were collected at 2, 4, 8, 16, 24, 36, 48, 72, 96 and 120 hours after dosing. In general, with increasing dietary

calcium, blood, plasma and several tissues indicated an increase in Se^{75} content on a per ml. or gm. basis. However, calculating the total blood volume of the animal, the total Se^{75} content of the blood was similar for all animals. Of the total blood Se^{75} content, about 72.5% was in the plasma portion. The highest content of Se^{75} was in the blood at 8 hours after dosing, which declined until 36–48 hours and plateaued to a level which remained constant throughout the 120-hour metabolism study. The main excretion was in the feces which contained 71.5% of the total Se^{75} excreted. During the metabolism study of Lot I (0.6% Ca), Lot II (1.2% Ca) and Lot III (2.4% Ca), urine contained 6.4%, 7.9% and 7.6% and the feces contained 18.2%, 16.3% and 19.0% of the Se^{75} dose, respectively. On a per gram basis, the concentration of Se^{75} in the kidney was the highest of 17 tissues sampled, while the total liver contained more of Se^{75} (7% of dose) than did the other tissues. The concentrations of Se^{75} in the tissues were as follows: Kidney > liver > spleen > small intestine wall > lung > large intestine wall > vertebrae > rib > heart > femur > teeth > large intestinal contents > skin > small intestine contents > muscle > bile > hair.

95. EFFECTS OF COPPER OXIDE, COPPER SULFATE AND CHLORTETRACYCLINE ON PERFORMANCE OF BABY PIGS. R. J. Bunch, V. C. Speer and V. W. Hays, *Iowa State University, Ames.*

Two experiments involving 224 pigs were conducted to study the effect of copper oxide, copper sulfate and chlortetracycline on pig gains, feed conversion, blood hemoglobin, and liver copper content during a feeding period from 2 to 8 weeks of age. In the first experiment four levels (0, 125, 250 and 325 p.p.m.) of copper (Cu) from copper oxide (CuO) and one level (250 p.p.m.) of copper from copper sulfate ($Cu_2SO_4 \cdot 5H_2O$) were compared. The average gain per pig and feed efficiency during the six-week experimental period were as follows: 30.3, 34.2, 33.2, 34.4, and 34.5 lb. gain, and 1.92, 1.78, 1.84, 1.78 and 1.76 lb. of feed per lb. gain for the 0, 125, 250 and 375 p.p.m. Cu from CuO, and 250 p.p.m. Cu from $Cu_2SO_4 \cdot 5H_2O$, respectively. The average blood hemoglobin values observed for each of the treatments were 10.1, 10.3, 10.0, 9.8 and 8.6 gm./100 ml. The average copper content (p.p.m.) found in the livers of eight pigs each from the control diet, 250 p.p.m. and 375 p.p.m. Cu from CuO and 250 p.p.m. Cu from $Cu_2SO_4 \cdot 5H_2O$ were 22, 32, 44 and 218, respectively. The second experiment compared the control ration with rations containing 250 p.p.m. Cu from CuO, 250 p.p.m. Cu from $Cu_2SO_4 \cdot 5H_2O$ or 50 mg./lb. chlortetracycline. The average total gain (lb.) and feed per pound of gain (lb.) were 32.6, 1.95; 37.9, 1.88; 38.8, 1.82; and 38.7, 1.91, respectively. After 6 weeks on experiment the average blood hemoglobin levels of 18 pigs per treatment were 10.5, 10.7, 10.9 and 10.8 gm./100 ml., respectively.

96. EFFECTS OF FLUORIDE, MAGNESIUM AND MANGANESE UPON CELLULOSE DIGESTION IN VITRO. C. C. Chamberlain and Wise Burroughs, *Iowa State University, Ames.*

Using standard washed cell, artificial rumen techniques, varying levels of fluoride (50, 100, 150, 200 ppm), magnesium (complete lack, 2, and 10 times normal), and manganese (complete lack) were used with normal basal medium to determine the effect on cellulose digestion. Duncans multiple range test indicated significant reductions (0.05) with 50 and 150 ppm of added F, highly significant reduction (0.01) at 200 ppm. Omission of Mg resulted in no difference. Adding 50 and 100 ppm of F to Mg deficient medium resulted in significant reduction, and 150 and 200 ppm F in highly significant reduction. Omission of Mn resulted in highly significant reduction and addition of 100 and 200 ppm F in still further significant reduction. Omitting both Mg and Mn resulted in highly significant reduction not further affected by F. Doubling Mg levels significantly increased digestion and only 200 ppm of F significantly reduced digestion.

With ten times normal Mg, 50 ppm F significantly increased digestion and 200 ppm F significantly decreased digestion. Addition of F reduced cellulose digestion but not in a straight line relationship. Omission of the Mn resulted in greater reduction than omission of Mg. Cellulose digestion, 50–60% of normal, occurs with omission of Mg and Mn, indicating microorganisms use at least two pathways in degradating cellulose. There was greater interaction between F and Mg than between F and Mn.

97. EFFECT OF AGE ON THE METABOLISM OF F^{18} IN CATTLE. C. C. Chamberlain, Sam Hansard and C. S. Hobbs, *University of Tennessee, Knoxville.*

Nine heifer calves' (7–11 months) and nine yearling heifers (17–22 months) were randomly allotted to three levels of fluoride intake (0, 100, 300 ppm added F). They were pair-lot-fed to equalize caloric intake. Fluoride intake level for 35–56 days prior to treatment with the isotope had no effect on the behavior of the isotope whether administered orally or intravenously. Calves dosed orally absorbed more F^{18} into the bloodstream and excreted more in the urine than yearlings. The isotope appeared rapidly in the saliva in both groups. Disappearance curves of intravenously administered F^{18} are similar to those of Ca^{45} and P^{32}. Calves had significantly greater ($P<.05$) disappearance of the isotope from the bloodstream at all times up to 345 minutes. There was not a significant increase in salivary level although, in general, it was somewhat higher in the calves. Calves had a significantly greater total urinary excretion. The bone concentration when corrected to a standard weight to reduce dilution effect was not significantly different although somewhat higher in the calves. Yearlings had a significantly higher concentration in the gastroneimus muscle and a highly significant increase in the bile. Calves metabolize the F^{18} more rapidly as indicated by removal pathways (urine, bone, saliva) and a higher concentration in yearling muscle. This is similar to the age differences previously reported for Ca^{45} and P^{32}. None of the fluoride levels used in this experiment affected blood glucose levels.

98. LIMITING AMINO ACIDS IN LOW PROTEIN SWINE RATIONS. R. E. Chance, E. T. Mertz and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Four feeding trials involving 132 weanling pigs, av. initial wt. 28 lb., were conducted with a 12% protein corn-soy basal. Amino acids were added at the expense of diammonium citrate to maintain isonitrogenous diets. Lysine was found to be the most limiting for good growth and feed utilization, followed by isoleucine. Tryptophan was borderline, while threonine was not limiting for growth but was limiting for satisfactory feed efficiency. Methionine, although calculated to be deficient according to NRC recommendations, exerted no beneficial effect upon overall performance, and, in one experiment, caused a slight growth depression when added to a diet containing supplemental lysine, isoleucine, tryptophan and threonine. The growth rate of pigs fed a 16% protein corn-soy ration was 38% greater than that obtained with a 12% protein diet fortified with the limiting amino acids lysine, isoleucine and tryptophan. Supplementation studies indicated that this difference was not the result of an inadequate level of arginine, aspartic acid, glutamic acid, or phenylalanine, but rather due to an insufficient level of valine, even though the amount in the basal diet exceeded NRC recommendations.

99. A RAPID METHOD OF QUANTITATIVELY ESTIMATING WHOLE GRAIN ESCAPING DIGESTION IN CATTLE UNDER FEEDLOT CONDITIONS. Wm. C. Christiansen and Wise Burroughs, *Iowa State University, Ames.*

Freshly voided feces (about 40 lb. per sample) were collected at random from cattle group-fed a shelled corn ration and confined in a pen with a clean hard surface. Each sample was thoroughly mixed, weighed and a small portion removed for dry

matter determination. The remaining sample was washed through a fine-mesh hardware cloth using a garden hose in which the whole kernels of corn were collected. The collected corn was dried and weighed. The amount of whole corn (dry basis) passing through the animal in the original 40 lb. of feces was related to the corn consumption of the pen of cattle based upon the ingredient make-up of the ration fed and an estimated dry matter digestion coefficient for the ration fed using average tabular values. The method when carried out several times in each of seven pens of cattle gave results with a high degree of repeatability and capable of demonstrating certain treatment differences between pens of cattle. The method is particularly useful since it can be carried out rapidly under feedlot conditions with little or no disturbance to cattle while on a high plane of nutrition.

100. UTILIZATION OF PREDIGESTED SOYA PROTEIN BY BABY PIGS. A. J. Clark, L. H. Neagle, V. W. Hays, D. V. Catron and V. C. Speer, *Iowa State University, Ames.*

Three experiments were conducted to study the influence of predigesting soybean oil meal (SBOM) and raw soya flour (RSF), with a bacterial protease (Pabst L-56-D), on utilization of the protein from these sources. In the first experiment SBOM predigested for 1, 6 or 9 hours resulted in increased rate of gain and improved feed efficiency as compared with untreated SBOM. In a second experiment, predigestion of RSF for 9 hours resulted in improved digestibility of protein (74 vs. 83%), total gain (6.7 vs. 10.3 lb.) and feed efficiency (2.09 vs. 1.68) as compared with the RSF basal. Predigestion of SBOM improved feed efficiency (1.50 vs. 1.41) and digestibility slightly (81 vs. 82%) as compared with the SBOM basal. Performance was better for the SBOM basal than for the predigested RSF. A third experiment compared the performance of pigs fed a SBOM basal with pigs fed SBOM predigested for 8 or 16 hours, each with or without supplemental methionine and lysine. A small improvement in efficiency of feed conversion was observed from predigesting the SBOM and also small improvements in gain and feed efficiency as a result of the amino acid supplementation.

101. DETERMINATION OF GOSSYPOL AND IRON IN THE LIVERS OF PIGS FED RATIONS CONTAINING COTTONSEED MEALS OF VARYING GOSSYPOL CONTENT. A. J. Clawson, F. H. Smith and E. R. Barrick, *North Carolina State College, Raleigh.*

Determinations were made of total and free gossypol and iron in livers of pigs fed eight cottonseed meals of known processing history. Gossypol content of the livers was found to be directly related, and iron content inversely related to total gossypol content of the ration. There was a trend toward lowered hemoglobin in the blood of pigs fed rations containing high levels of gossypol. The percent total gossypol of the ration, percent total gossypol in the livers and p.p.m. iron in the livers, respectively, are presented in order of descending total gossypol in the ration, as follows: 1.35, .0189, 306; 1.24, .009, 454; 1.24, .0103, 468; 1.09, .0088, 529; .81, .0074, 549; .92, .0065, 506; .82, .0088, 542; .35, .0024, 871. A crystalline compound was obtained from the pig liver extracts which appeared to be the same as pure dianilinogossypol under microscopic examination. The spectral curve for the crystallized compound showed it to be identical with that of pure dianilinogossypol.

102. RATIONS FOR CREEP FEEDING LAMBS. J. H. Cline, W. J. Tyznik and J. K. Judy, *Ohio State University, Columbus.*

Two creep feeding experiments were conducted in 1959 and 1960, employing 195 lambs which were randomly allotted to four nutritional treatments at approximately

10 days of age. The creep rations were self-fed and consisted of dehydrated alfalfa pellets as the roughage and a concentrate of cracked shelled corn or cracked shelled corn and soybean oil meal pellets fed separately. Average daily gain, feed consumption, 120-day weights, average age at sale and feed costs were compared in evaluating the rations. Lamb response to alfalfa pellets as the only creep feed was very good until about 60–70 days of age then decreased rapidly. Best results were obtained with dehydrated alfalfa pellets plus a combination of shelled corn and soybean oil meal pellets. Creep feeding increased daily gain by 0.25 lb. per day.

103. PHOSPHORUS LEVELS AND CALCIUM-PHOSPHORUS RATIOS FOR YOUNG AND GROWING-FINISHING SWINE. G. E. Combs, J. M. Vandepopuliere, H. D. Wallace and M. Koger, *University of Florida, Gainesville.*

Pigs weaned at 2 weeks of age were individually fed semi-synthetic or fortified corn-soybean meal rations. The semi-synthetic rations were fed at phosphorus levels of 0.24, 0.36, 0.48, 0.60 and 0.72% and Ca: P ratios of 1.2:1 and 2:1. As measured by fibula ash, fibula density, gain, feed efficiency and physical observation phosphorus levels of 0.24 and 0.36% were inadequate. With the exception of fibula density no statistically significant differences existed among phosphorus levels of 0.48, 0.60 and 0.72%. Statistically significant differences in gain, feed efficiency and fibula density were found between the Ca:P ratios. The corn-soybean meal ration was fed at phosphorus levels of 0.40, 0.44 and 0.48% and Ca:P ratios of 0.9:1, 1.2:1, and 1.5:1. At 7 weeks of age the left fibula was surgically removed from all pigs. These pigs were continued on their respective treatments and slaughtered at approximately 200 lb. body weight. Data collected at 7 weeks showed a statistically significant linear increase in growth rate, fibula ash and fibula density with increasing phosphorus levels. Statistically significant linear increases were observed with gain and fibula density as the Ca:P ratios narrowed and widened respectively. Terminal data showed that all of the previously mentioned criteria plus femur ash, density and length exhibited a statistically significant linear response to increasing phosphorus levels. As the Ca:P ratio widened from 0.9:1 to 1.5:1 only ash and density of the fibula and femur exhibited a statistically significant linear response.

104. LEVELS OF SPIRAMYCIN AND TYLOSIN FOR GROWING-FINISHING SWINE. J. H. Conrad, D. M. Henricks and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

A total of 160 Duroc weanling pigs were used in two growing-finishing experiments that were conducted on concrete. The treatments, levels of antibiotics in grams per ton, daily gains first 56 days, daily gains from 29 to 200 lb. and feed per 100 lb. of gain, respectively, in Expt. 1 were: (1) control, 1.24, 1.54 and 328; (2) chlortetracycline 20, 1.46, 1.68, and 311; (3) spiramycin 10, 1.46, 1.64 and 322; (4) tylosin 20, 1.55, 1.69 and 315; (5) tylosin 15 and penicillin 5, 1.52, 1.67 and 320; (6) streptomycin 15 and penicillin 5, 1.43, 1.65 and 319. All five of the experimental treatments significantly increased daily gains (1% level) during the first 56 days but the differences in daily gains were not statistically significant when the pigs reached 200 lb. The treatments, levels of antibiotics in grams per ton from initial to 100 lb. and 100 to 200 lb., daily gain from 28 to 100 lb. and feed per 100 lb. of gain from 28 to 100 lb., respectively, in Expt. 2 were: (1) control, no antibiotic, 1.22 and 270; (2) chlortetracycline, 20–10, 1.30 and 262; (3) tylosin, 10–5, 1.42 and 250; (4) tylosin, 20–10, 1.38 and 257; (5) tylosin, 40–20, 1.44 and 248; (6) spiramycin, 10–5, 1.39 and 253; (7) spiramycin, 20–10, 1.43 and 244; (8) spiramycin, 40–20, 1.49 and 252. Pigs in lots 4 and 6 gained significantly faster (5% level) and pigs in lots 3, 5, 7 and 8 gained significantly faster (1% level) than the control pigs.

105. USE OF AN ELECTRONICALLY COMPUTED LEAST-COST RATION IN TESTING THE ADEQUACY OF THE FEEDING STANDARD FOR EARLY-WEANED PIGS. E. W. Crampton, L. E. Lloyd and D. N. Mowat, *Macdonald College (McGill University), Canada.*

Feeding Standards are tables of data assembled from independently conducted feeding tests. The application of electronic computations to livestock ration formulation opens for the first time a practical way for testing, in feeding trials, the nutritional adequacy of livestock feeding standards as complete units, in that it makes feasible ration formulae that meet, within tolerances that may have been specified, the concentration of all nutrients included in the standard. This paper reports the performance of 96 early-weaned (21-day) pigs fed individually in a comparative feeding trial for a 6-week period on an electronically computed least-cost ration ($73. per ton), as compared to a nutritionally proven early-weaning ration ($99. per ton) originally developed in this department. The rations were offered to the pigs *ad libitum* as dry meal in self-feeders, with water available from individual fonts in each pen. The voluntary daily feed intake of 1.9 lb. of the electronically computed ration averaged 11% less than that of the control. This was significant at P=.01. The gains averaged 0.92 lb. per pig, per day, and differed by only 1% between the groups on the two rations. Thus there was an improvement in feed efficiency of the order of 10% (significant also at P=.01). This improvement is presumably to be credited to an improved balance of the nutrient assortment in the "computed" formula, and especially to a reduction of disregarded nutrient excesses in the control ration.

106. EFFECT OF PHYSICAL FORM OF THE RATION ON STEER PERFORMANCE AND CERTAIN RUMEN PHENOMENA. A. E. Cullison, B. M. Campbell and R. W. Walker, *University of Georgia, Athens.*

In the first of two feeding trials, three lots of 12 steer calves each were fed a complete finishing ration in three different physical forms over a period of 196 days. Group I received a full feed of concentrates and, separately, long hay. Group II received the same combination of feeds in the same proportions, ground and mixed, and self-fed. Group III received a similar ration in the pelleted form self-fed. The average daily feed consumption and the average daily gain, respectively, for each of the groups were as follows: Group I, 19.7, 2.41; Group II, 19.7, 2.53; Group III, 16.8, 2.17. In the second trial five groups of 10 steer calves each were fed through a 210-day finishing period. The feeding program for Groups I through III was identical with that for the three groups in the first trial. Groups IV and V were fed similarly to Groups II and III except that the former were provided with oat straw on an *ad libitum* basis, in addition to the basic ration. The average daily feed consumption and the average daily gain, respectively, for the five groups in the second trial were as follows; Group I, 17.1, 2.10; Group II, 15.4, 2.03; Group III, 13.5, 1.64; Group IV, 17.4 + 1.4 (straw), 2.27; Group V, 17.1 + 1.5 (straw), 2.25. Significantly lower rumen pH levels were found among those steers receiving pellets only. Essentially no normal rumination and cud chewing were noted among the animals receiving either pellets only or the completely ground ration. A distinctly abnormal rumen wall condition resulted among both of the latter groups.

107. INFLUENCE OF MINERALS AND FAT ADDITIONS UPON RATION DIGESTIBILITY AND PERFORMANCE OF FATTENING LAMBS. Kenneth L. Davison and Walter Woods, *Iowa State University, Ames.*

Studies were conducted with lambs to determine the efficiency of $CaCO_3$, $CaCl_2$ and $MgCO_3$ in alleviating the depressing effects of corn oil upon digestibility of a ration containing 46% corncobs. Calcium added to the basal ration (0.3% calcium)

at the 0.4% level as chloride or carbonate alleviated the depressing effects of 5% corn oil upon digestibility of organic matter, protein and cellulose. Magnesium added at the 0.25% level was without effect. In another study, 10% corn starch did not decrease digestibility of organic matter, protein and cellulose to the extent of 5% corn oil. Calcium increased digestibility of these components and increased digestible energy in both the corn oil and starch rations. Calcium or corn oil did not alter the digestibility of a ration containing 40% alfalfa hay. The addition of 5% corn oil saved about 1 lb. feed per lb. gain in a fattening study when the ration contained 40% alfalfa hay but did not when it contained 40% corncobs. Rate of gain, carcass grade and dressing percent were not significantly affected. Three additional fattening trials were conducted in which 5% stabilized white grease and multiple calcium levels were added to rations containing 40% corncobs. Grease tended to reduce feed consumption in all trials and to reduce gain in one trial; however, feed conversion, carcass grade and dressing per cent were not affected. Calcium, at the levels studied, did not materially influence any of these factors. Trace minerals (Fe, Cu, Mn and Co) added with calcium were ineffective in improving gain, feed conversion, dressing per cent and carcass grade.

108. EFFECT OF LEVEL OF ENERGY INTAKE DURING GESTATION ON CONDITION AND PERFORMANCE OF SWINE. B. T. Dean and L. F. Tribble, *University of Missouri, Columbia.*

A series of five experiments were conducted to study the effect of energy level on the reproductive performance of sows and gilts. In all trials, a constant and equal amount of protein supplement containing vitamins and minerals was fed to each group. Variation in energy level between groups was secured by feeding different levels of shelled corn during the gestation period. One group (normal) was fed to make the desired gain in weight as recommended by N.R.C. The other group was fed a limited amount of shelled corn to make approximately two-thirds of the gain of the normal-fed group. Normal-fed sows and gilts gained an average of 114 lb. during gestation as compared to an average of 70 lb. for the limited groups. Backfat probes taken at breeding, 109th day of gestation, and at weaning showed that the normal-fed groups tended to gain condition from breeding to farrowing followed by a loss in condition during lactation, whereas, limited-fed sows and gilts lost in condition during the gestation and lactation periods. In all trials, limited-fed sows and gilts farrowed and weaned larger litters than the normal-fed groups, and, in all but one trial, they weaned a greater percentage of pigs farrowed. The average weaning weight tended to favor normal-fed sows.

109. EFFECT OF BALL-MILLING UPON *IN VITRO* DIGESTIBILITY OF CELLULOSE OF MATURE FORAGES. Burk A. Dehority and Ronald R. Johnson, *Ohio Agricultural Experiment Station, Wooster.*

The theory has been proposed that deposition of lignin around the cellulose as an "encrusting substance," rather than total concentration of lignin, could be responsible for the decreased digestibility of forages as they mature. To study this possibility forages were ground in a ball-mill. If such a protective sheath of lignin exists, ball-milling could increase the amount of cellulose available for digestion through physical rupture of this coating. Rates of cellulose digestion for fourth stage timothy (seed ripe), ball-milled for 0, 6, 24 and 72 hr., were determined *in vitro*. After 48 hr. fermentation, 42.4, 57.7, 66.1 and 78.0% of the cellulose had been digested respectively. The rates of cellulose digestion for four stages of timothy (vegetative, heading, headed and seed ripe), with and without ball-milling were determined *in vitro*. Percent cellulose digestion after 48 hr. for the four stages without ball-milling (40 mesh) were 85.3, 75.7, 62.4 and 45.6 respectively, while after ball-milling 72 hr. the percent

digestion was 93.0, 88.5, 85.4 and 81.0. Similar data were obtained with two stages each of brome and orchard grass. In further work, predigestion of fourth stage timothy for 48 hr. was carried out and the residue isolated. Less than 2% of the cellulose remaining in this residue was digested in a second 48-hr. fermentation. However, when a portion of this residue was ball-milled 64% of the cellulose was digested. The above data would tend to confirm the "encrusting" theory of lignin deposition.

110. A CELLULOLYTIC FACTOR IN SILAGE EXTRACTS, ISOLATION AND TENTATIVE IDENTIFICATION. A. L. Donoho, G. B. Garner and M. E. Muhrer, *University of Missouri, Columbia.*

The cellulolytic factor in an aqueous extract of silage has been concentrated 600 fold. This concentration was brought about by a series of adsorptions and elutions employing Norit-A, Lloyd's reagent, Amberlite 1R-4B and 80% ethanol or ammoniacal ethanol, respectively. The final product was a light brown, non-hydroscopic powder. Assay for the factor was by the artificial rumen technique using solka-floc, casein, urea, ammonium carbonate, glucose, cobalt and a phosphate-carbonate buffer as a basal with a washed cell inoculum. Residual cellulose was determined by the modified Crampton-Maynard method. Results with extracts added to washed cells were equal to whole rumen fluid inoculum, both digesting 62% of the cellulose present in 22 hours. All the enhancing activity was found in the final preparation. Chemical characterization including infra-red and microbiological assay indicates the factor to be biotin. The activity was destroyed by heating with 1N hydrochloric acid as was the activity of pure biotin. In a comparison of biotin at various levels both with and without the extract, results indicate the major portion of the activity to be related to the concentration of free biotin.. A biotin level of 0.05 microgram/ml. of media was found to be optimum for *in vitro* cellulose digestion.

111. CRYSTALLINE AMINO ACID MIXTURES AS THE SOLE SOURCE OF NITROGEN FOR THE BABY PIG. W. A. Dudley, D. E. Becker, A. H. Jensen and S. W. Terrill, *University of Illinois, Urbana.*

Mixtures of the ten essential amino acids simulating the composition of (A) an amino acid diet previously used successfully with older swine, (B) a calculated amino acid requirement for swine, (C) an amino acid diet designed for rats, (D) the carcass composition of the pig, and (E) an amino acid diet designed for chicks, were compared for their ability to promote pig growth. Ten percent L-glutamic acid provided the non-essential nitrogen in each diet. Pigs approximately 1 to 2 weeks of age were placed on a dry casein-lactose diet for an adjustment period of 7 days. The experimental diets were then fed to treatment groups of four pigs for a period of 1 to 3 weeks. The average daily gain for the casein diet and amino acid mixtures A, B, C, D, and E was 0.26, 0.07, 0.10, 0.16, 0.08, and 0.5 kg., respectively for the first experiment and 0.32, 0.06, 0.13, 0.10, 0.07, 0.03 kg. respectively for the second experiment. A third experiment was a complete factorial with three levels (4.18, 8.36, and 12.54%) of essential amino acid mixture "B" in combination with 5 and 10% L-glutamic acid. An additional treatment consisted of 8.36% essential amino acids, 10% L-glutamic acid, and 3% casein. The only effect of changing the amino acid level was a slight reduction in gain on the low level of essential amino acids. The addition of 3% casein increased pig gains approximately 75%.

112. EFFECTS OF CORTISONE ON LAMB PERFORMANCE. I. A. Dyer, John Clark and M. W. Galgan, *Washington State University, Pullman.*

Two experiments have been conducted in which cortisone was either implanted or fed to fattening lambs. In the first experiment, 50 grade lambs weighing 77 lb.

were allotted at random into five groups of 10 each. Groups 1, 2, 3, and 4 were implanted with 12 mg. cortisone acetate at 55, 38, 26 and 12 days pre-slaughter, respectively. Group 5 served as the control. Average daily gain, on a shrunk basis, was 0.22, 0.20, 0.20, 0.16 and 0.16 for the five groups, respectively. The USDA grade was 10% higher for the cortisone-implanted lambs. These differences were confirmed by both specific gravity measurements and by dressing percentage. No significant differences were observed in adrenal weights. In a second experiment, 50 grade lambs weighing approximately 82 lb. each were divided into five lots of 10 each. Group 1 served as the control while groups 2, 3, and 4 were fed 20, 100 and 500 mg. cortisone acetate daily. Lambs in group 5 were implanted with 144 mg. cortisone acetate. These lambs were fed a ration containing 66% concentrate and 34% roughage. Rates of gain were improved by the cortisone during the first 18 days, although at the end of the 36-day feeding period, no weight advantage favoring the cortisone was observed. The average daily gains were 0.62, 0.50, 0.60, 0.59 and 0.51 lb. for groups 1–5, respectively.

113. EFFECT OF NUTRITION ON THE INCIDENCE OF A CONGENITAL DEFORMITY—CROOKED CALVES. I. A. Dyer, G. A. Harris and M. E. Ensminger, *Washington State University, Pullman.*

An anomaly called crooked calves occurs in California, Oregon, Idaho, Montana and Washington. This congenital deformity is characterized by either curved forelegs, neck or spine and apparently is not under the influence of either genetics or disease. In areas where this anomaly occurs the incidence has ranged from 0 to 100%. Two small ranches (one with no history of this deformity and the other with a 100% deformity for the past 3 years, were selected for a comparative study. Soil on the two ranches classified, sampled, and analyzed both chemically and spectrographically showed no consistent difference in composition. Plant samples of the predominating species *(Agropyron spicatum, Festuca idahoensis,* and *Bromus tectorum)* from the different soil types taken at monthly intervals from April to August and at bi-monthly intervals thereafter showed no significant difference in proximate fraction composition of comparable grasses between these two ranches. A taxonomic classification showed six toxic plants *(Lupinus sericeous, Astragalus purshii, Delphinium nelsonii, Zigadenus gramineus, Amsinkia retrorsa* and *Ustilago bullata)* on each of the ranches. Water samples from each ranch were spectrographically analyzed. Water from the ranch with normal calves averaged 1700 ppm Mn; whereas, water from the ranch producing deformed calves contained only 20 ppm. Copper and iron were also higher in water from the ranch producing normal calves. No consistent difference was observed in bone composition of the normal and deformed calves.

114. LIGNIN EXCRETION BY CATTLE FED A MIXED RATION. C. J. Elam and R. E. Davis, *Beef Cattle Research Branch, AHRD, ARS, USDA.*

Lignin excretion patterns were determined for beef heifers fed a complete pelleted ration composed of: corn and cob meal, 51.5%; cottonseed meal, 13.5%; molasses, 10%; and timothy hay, 25%. Three heifers were fed on each of four feeding schedules as follows: (1) limited-fed once daily, (2) full-fed once daily, (3) full-fed twice a day, and (4) allowed to eat *ad libitum.* Lignin analyses of 96 feces samples collected at 3-hr. intervals for 24 hr. indicated that the concentration of lignin in the feces was not affected by time of sampling or feeding schedule. Expressed as percentage of the daily mean, the extreme range in individual observations was from 88 to 109%. The standard error was ± 0.42%. Compared to chromic oxide, which was mixed in the entire ration, lignin was excreted in a relatively uniform manner. Chromic oxide concentrations in these same samples ranged from 74 to 135% of the daily mean (J. Animal Sci. 18:718, 1959) with a standard error of ± 1.12%.

A conventional total collection digestion trial was conducted with four steers fed the above ration. Following a 10-day collection period, feces samples were taken at 3-hr. intervals for 24 hr. Results of this experiment confirmed the earlier work in that lignin concentration in the feces varied little during a 24-hr. period. Apparently, digestion of lignin occurred, however; since, only 87.1% of the lignin was recovered in the feces.

115. WHOLE COTTONSEED AND COTTONSEED MEAL IN FATTENING LAMB RATIONS. Henry Elliott, R. C. Mowery and Ralph M. Durham, *Texas Technological College, Lubbock.*

No differences were found between daily gains or carcass grades of lambs fed rations supplemented with cottonseed and cottonseed meal. However, there was an advantage in feed conversion in favor of the lambs receiving cottonseed. This advantage was sufficient to make the ration more economical with the cottonseed—cottonseed meal price relations which existed at the time of this trial. No advantage was found for a standard high roughage ration which is widely used. This study was conducted with 180 Rambouillet feeder lambs. The lambs were sorted into 9 treatment groups of 20 lambs each. The heavier 6 groups were put on feed November 21 for a 50-day period. They were fed rations containing high vs. low roughage, and whole cottonseed vs. cottonseed meal. The remaining 3 groups were put on feed January 16 for a 58-day period. They were fed rations containing high vs. low grain, and cottonseed vs. cottonseed meal. All rations were pelleted. The whole cottonseed were ground and put into the pellet. Aureomycin was fed at the beginning of the feed period for 2 weeks.

116. FURTHER STUDIES ON MOLYBDENUM AS A POSSIBLE COMPONENT OF THE "ALFALFA ASH FACTOR" FOR SHEEP. W. C. Ellis and W. H. Pfander, *Texas A. and M. College, College Station and University of Missouri, Columbia.*

A beneficial role of molybdenum, similar to that of alfalfa ash, of stimulating cellulose digestibility and readiness of ration consumption by sheep pair-fed semipurified rations has been reported (*J. Animal Sci.* 17:180). Three subsequent experiments have been conducted to investigate further molybdenum as a possible component of the "alfalfa ash factor." The first experiment utilized pelleted semipurified rations (*J. Animal Sci.* 17:180) containing varied copper and molybdenum levels and lot-fed to four groups of four western feeder lambs for 89 days. The amounts of copper sulfate pentahydrate and sodium molybdate dihydrate (gm./1000 lb. ration) added, and the lambs' average gains and feed consumption (lb./day) respectively were: 8.6, 0.0, 0.18, 1.71; 8.6, 3.0, 2.6, 1.73; 17.2, 0.0, 0.19, 1.75; 17.2, 3.0, 0.14, 1.54. In a second trial, additions of alfalfa ash (2.2% of ration) to a semipurified corn cob ration stimulated cellulose digestibility whereas sodium molybdate additions supplying molybdenum equivalent to that in the alfalfa ash rations (0.4 ppm) did not. A third trial utilized practical type pelleted rations containing either 60% cottonseed hulls or corn cobs in combination with either 5% corn syrup or corn oil. Alfalfa ash additions stimulated free choice feed consumption of all ration combinations whereas molybdenum additions, equivalent to that contained in the alfalfa ash rations (0.4 ppm) did not. Collectively, these experiments exclude molybdenum *per se* as the beneficial component of alfalfa ash in stimulating feed consumption and cellulose digestibility of poor quality roughage rations.

117. EFFECT OF DIETARY ENERGY AND PROTEIN LEVELS ON THE SEVERITY OF NITRATE POISONING IN RUMINANTS. R. J. Emerick and L. B. Embry, *South Dakota Agricultural Experiment Station, Brookings.*

Rations varying in energy and protein content were fed with and without added nitrate to determine the effect of such variations on the severity of nitrate poisoning.

Eight groups, each composed of eight lambs, received the following rations with and without 3% $NaNO_3$: (1) brome hay (low-energy); (2) 50% brome hay + 10% rolled corn (high-energy); (3) 90% brome hay + 10% soybean oil meal (low-energy, high-protein); (4) 50% brome hay + 40% rolled corn + 10% soybean oil meal (high-energy, high-protein). The sheep receiving the higher energy rations developed the most severe methemoglobinemia. During the period in which methemoglobinemia was most severe, average methemoglobin values for the high-energy groups were approximately 50% higher than for the corresponding low-energy groups and reached a peak of 5.5 gm. percent (equivalent to 40.6% of the total hemoglobin). No significant differences were observed that could be attributed to differences in the dietary protein levels. It is of further interest that the high level of $NaNO_3$ fed in this experiment appeared to have no detrimental effect on weight gains.

118. DIGESTIBILITY OF GROUND AND FLAKED SOYBEAN HULLS BY BEEF STEERS. R. R. Garrigus, A. L. Neumann and G. E. Mitchell, Jr., *University of Illinois, Urbana.*

Ten yearling Hereford steers were used in a reversal-type digestion trial designed to determine the digestible nutrients in ground and flaked soybean hulls. Seven-day collection periods were preceded by nine-day preliminary periods. Twelve pounds of soybean hulls were fed per head daily in two equal feedings throughout the trials. During the first experimental period, six steers received ground soybean hulls and four steers received the flaked soybean hulls. Twelve steers were started but two steers failed to adjust to the metabolism crates. Average analyses (%) for the ground and flaked soybean hulls, respectively, were: dry matter, 92.24 and 89.01; crude fiber, 37.17 and 31.64; ether extract, 1.47 and 2.91; nitrogen free extract 40.00 and 40.65; crude protein, 9.72 and 10.19; and ash, 3.86 and 3.32. Average apparent digestion coefficients were: 59.7 and 69.5 for dry matter, 59.2 and 66.2 for crude fiber, 65.8 and 79.7 for ether extract, 70.8 and 77.4 for nitrogen free extract, 45.9 and 54.9 for crude protein, and 58.7 and 68.9 for gross energy in the ground and flaked soybean hulls, respectively. The advantages in favor of the flaked soybean hulls were highly significant in all cases.

119. EFFECTS OF ENERGY IN STEERS FED CORN-SOYBEAN MEAL RATIONS. R. S. Gordon and E. S. Erwin, *Monsanto Chemical Company.*

Replicated pens of 11 steers each were fed for 215 days isonitrogenous rations (25% protein) of cracked corn and soybean meal with the following additions: (1) none, (2) 7.25% tallow, (3) 7.25% tallow plus 30% alfalfa hay, and (4) 30% alfalfa hay. The percent fiber of the rations was (1) 1.9, (2) 1.9, (3) 8.2, and (4) 8.9. Bloat was observed only in steers fed (4). The average daily gain, feed per pound gain, and pounds feed per day was (1) 1.94, 7.44, 14.4, (2) 2.17, 6.60, 14.3 (3) 2.09, 7.60, 15.9, (4) 1.63, 9.31, 15.2. Added fiber in addition to what was contained in corn and soybean meal was not required by steers for adequate growth and well-being. While the addition of dietary calories by replacing hay with grain reduced feed consumption, calorie increase by tallow addition to either (1) or (4) did not alter total feed intake. Added calories supplied by tallow were more efficiently utilized in hay-containing ration (3) than in all-grain rations (2). Rations (1) and (3) were calculated isocalorically. While feed per pound of gain was similar, these data would suggest that the caloric content of hay was over evaluated when calories were estimated from T.D.N. values. These results demonstrate that steers can be fed like monogastric animals and that roughages play little or no role in steer rations other than by diluting the caloric density of the ration.

120. VALUE OF SUPPLEMENTAL LYSINE AND METHIONINE ON HIGH UREA FATTENING RATIONS FOR BEEF STEERS. W. H. Gossett, T. W. Perry, M. T. Mohler and W. M. Beeson, *Purdue University, LaFayette, Indiana.*

Two experiments were conducted to determine the value of supplemental amino acids (lysine and methionine) in beef cattle rations containing high levels of urea. In one experiment, supplements containing from 3.7 (40% protein) to 18.5% (72% protein) urea were compared on a protein equivalent basis with a 32% supplement containing no urea. Without supplemental lysine, daily gains ranged from 1.91 to 2.15 lb. (av., 2.02 lb.) when the various levels of urea were fed. When 10 gm. of l-lysine HCl was fed per steer daily with the various levels of urea, daily gains ranged from 2.03 to 2.22 lb. (av., 2.14 lb.). Steers fed the supplement containing no urea gained 2.21 lb. with no lysine and 2.16 lb. with supplemental lysine. In the second experiment, either 10 gm. of supplemental lysine or methionine, or both, were fed with the 32% supplement containing no urea or the 64% supplement containing 14.8% urea. Without supplemental amino acids, daily gain was 2.33 for the 32% supplement as compared to a daily gain of 2.32 when both amino acids were added. Average daily gain for the steers on the 64% supplement was 2.06 with no amino acids, 2.24 with lysine, 2.24 with methionine, and 2.17 with both lysine and methionine. The feeding of 80 mg. of zinc bacitracin per head daily to one-half of the steers in the second experiment had no effect on rate of gain or feed efficiency.

121. ROUGHAGE-CONCENTRATE RATIO AND RELATIONSHIP OF CALCIUM TO FAT-DEPRESSED CELLULOSE DIGESTION WITH SHEEP. R. B. Grainger, R. Anggorodi and J. W. Stroud, *University of Kentucky, Lexington.*

Four metabolism trials were conducted with four mature wethers per treatment in two phases of an investigation, each phase being a 3 x 4 factorial design. In phase 1, a study designed to investigate the effect of roughage to concentrate ratio and corn oil on cellulose digestion, rations with three ratios (80/20, 65/35 and 50/50) and four levels of corn oil (0, 2, 4 and 8%) were fed to wethers at a level of 700 gm. daily. In phase 2, designed to study the effect of levels of Ca and corn oil on cellulose digestion, rations with three levels of Ca (2.5, 5.0 and 10.0 gm/wether/day) and four levels of corn oil (0, 2, 4 and 8%) were fed as in phase 1. The 8% level of corn oil in the 50/50 rations significantly decreased cellulose digestibility, and in the 65/35 and 80/20 rations significantly decreased cellulose and dry matter digestibility. The 4% level of corn oil in the 65/35 and 80/20 rations significantly decreased dry matter digestibility, and in the 80/20 it decreased cellulose digestibility. The roughage to concentrate ratio across the levels of corn oil supplement had no effect on dry matter digestibility. In phase 2, the magnitude of decrease in apparent digestibility of protein, cellulose, dry matter and calcium caused by 2, 4 and 8% corn oil was related to the gm. of Ca added to the daily intake of the wethers. A quantitative relationship was shown to exist between Ca and corn oil, when apparent digestibility was the criterion.

122. CATION-FAT EFFECT ON CELLULOSE DIGESTIBILITY BY SHEEP. R. B. Grainger, M. C. Bell, J. W. Stroud and F. H. Baker, *University of Kentucky, UT-AEC-ARP.*

Three balance trials were conducted with four mature wethers per treatment. Semi-purified rations, 700 gm. daily intake per wether were fed. The addition of 7% corn oil to the basal ration (BR) in trial 1 significantly ($P<0.01$) depressed apparent digestibility of calcium and cellulose. Distillers Dried Solubles added to the BR, maintaining an iso-nitrogen and iso-cellulose intake significantly increased ($P<0.05$) calcium and cellulose apparent digestibility over the 7% corn oil containing ration.

Addition of 4.4 gm. Ca/wether/day to the corn oil ration produced a similar effect ($P<0.01$). As the apparent digestibility of calcium decreased the insoluble fecal soap excretion increased. There was no relationship between fecal soap and cellulose digestion. In trial 2, Ca-45 was used to obtain true digestibility of Ca. Addition of 5% corn oil to the BR significantly decreased apparent and true digestibility of calcium and cellulose. Supplementation of the ration containing 5% corn oil with 3.7 gm. Ca/wether/day significantly increased cellulose and apparent and true digestibility of calcium. Fecal soap excretion was related to apparent and true digestibility of calcium but not cellulose digestibility. In trial 3, Ca (4.4 gm.), Fe (6.2 gm.), K (8.6 gm.), Zn (7.2 gm.) and Mg (2.6 gm.) were added to daily intake of the ration containing 7% corn oil. Cations were added on an equivalent weight basis. Ca or Fe alleviated or partially alleviated the effect of corn oil on cellulose digestibility. K further increased the corn oil effect, and Mg and Zn caused the wethers to quit eating after 7 days of the preliminary period.

123. A BIOLOGICAL EVALUATION OF UREA WITH MATURE WETHERS. R. B. Grainger, D. Oberleas, F. H. Baker and J. W. Stroud, *University of Kentucky, Lexington.*

Data from two metabolism trials were used in an evaluation of total urea supplementation at 3.02, 5.03, 8.08, 11.10 and 14.15% protein equivalence. Metabolic fecal protein on a semi-purified protein-free ration was 2.35 $\pm$ 0.30 gm. of protein per 100 gm. of dry matter intake. Endogenous protein was 0.19 $\pm$ 0.014 gm. of protein per kilogram body weight. Apparent protein digestibility paralleled increases in protein level. Five percent protein equivalence was required to maintain nitrogen integrity. Biological values for 3, 5, 8, 11 and 14% protein equivalent levels were 69, 68, 47, 45 and 37, respectively. Nitrogen metabolism was studied in a third experiment with semi-purified rations that contained (1) *total* isolated soybean protein, (2) 50% isolated soybean protein—50% urea and (3) 100% urea, fed at 8% protein or protein equivalence level, two and four times per day. Four times per day did not significantly affect the digestibility of the rations fed. Total urea supplementation gave significantly lower biological values and nitrogen balance. In trial 4 the fecal protein excreted per 100 gm. dry matter excreted on the 5, 8 and 11% protein rations of trials 1 and 2 was used as fecal metabolic protein corrections in calculating the true protein digestibility, biological value and net utilization of isolated soybean and Distillers Dried Solubles at 5, 8 and 11% protein level. The true protein digestibility and biological values for the two protein sources suggest a new concept of determining fecal metabolic protein in ruminants.

124. EFFECT OF ENZYMES ON NUTRIENT DIGESTION BY WETHERS. R. B. Grainger and J. W. Stroud, *University of Kentucky, Lexington.*

Two conventional metabolism studies with a 10-day preliminary followed by a 10-day total urinary and fecal collection were conducted with four mature wethers per experimental group. The semi-purified basal ration contained: cottonseed hulls, 50; Drackett protein 9.9; corn oil, 2.0; corn starch, 35.8; bone meal, 1.6; trace mineralized salt, 0.5; magnesium sulfate, 0.2% and adequate vitamins A and D to meet NRC requirements. In trial 1 the addition of 1 gram per 700 gm. daily intake of the basal ration significantly ($P<0.01$) increased apparent digestibility of dry matter, (60.1 vs. 66.8); crude cellulose, (47.9 vs. 60.1) and crude protein (48.9 vs. 55.5). In trial 2, to partition the effect of the multiple enzyme preparation six groups of wethers were fed basal ration (BR), BR plus multiple enzyme preparation, BR plus gumase, BR plus amylase, BR plus protease and BR plus the three separate enzymes. One gram of the multiple enzyme preparation was added per day per wether and the single enzyme preparations were added at equivalent levels. The multiple enzyme preparation

improved apparent dry matter, crude cellulose and crude protein in trial 2. The individual enzymes gumase and amylase and the combination of all three significantly improved dry matter digestibility (59.9 vs. 66.4, 65.9 and 67.5, respectively). Gumase, amylase, and protease and the combination of the three enzymes significantly increased crude cellulose digestibility (41.4 vs. 55.8, 54.8, 50.9 and 53.3, respectively). The combination of the three enzymes significantly increased crude protein digestibility and nitrogen balance.

125. TENNECETIN, BACITRACIN AND AUREOMYCIN FOR GROWING FINISHING SWINE. S. A. Griffin, *University of Tennessee Agricultural Experiment Station, Knoxville.*

Forty-eight weanling Duroc and Hampshire pigs were allotted to 12 lots on the basis of weight, sex and breed. Two lots of four pigs each were randomly assigned to each of the following treatments: (1) Control; (2) Control plus 200 units of tennecetin per pound; (3) Control plus 10 mg. bacitracin per pound (bacitracin methylene disalicylate); (4) Control plus 10 mg. chlortetracycline per pound; (5) Control plus 200 units tennecetin and 10 mg. bacitracin per pound; and (6) Control plus 200 units tennecetin and 10 mg. chlortetracycline per pound. The pigs were fed in concrete pens from an average weight of 48 lb. to a weight of about 200 lb. Treatment number, average daily gain and feed required per 100 pounds of gain were, respectively: (1) 1.55, 394; (2) 1.57, 372; (3) 1.71, 384; (4) 1.66, 395; (5) 1.68, 395; (6) 1.66, 370. There were no statistically significant ($P<.05$) differences among the treatments in average daily gain or in feed required per 100 pounds of gain.

126. COMPARISON OF SUGAR AND ARTIFICIAL SWEETNESS IN BABY PIG DIETS. L. E. Grinstead, V. C. Speer, D. V. Catron and V. W. Hays, *Iowa State University, Ames.*

One hundred and eight two-week-old pigs were used in two preference trials to compare the palatability of starter diets, as measured by relative consumption, containing no sweetener (basal), an artificial sweetener, sucrose or a combination of sucrose and the artificial sweetener. In trial I a 15% sucrose or equivalent level of sweetener was used, whereas in trial II a 10% level of sucrose or sweetener was used. The artificial sweetener used was 90% saccharin sodium and 10% sodium cyclamate. Two diets were offered free choice in each pen. The feeders were interchanged within the pen three times per week. In trial I, the comparisons and relative consumption percentages were: (1) basal vs. sucrose, 13%:87%; (2) basal vs. artificial sweetener, 64%:36%; (3) basal vs. combination of sucrose and artificial sweetener, 1%:99%; (4) sucrose vs. artificial sweetener, 92%:8%; and (5) sucrose vs. combination of sucrose and artificial sweetener, 93%:7%. In trial II the comparisons and relative consumption percentages were: (1) basal vs. sucrose, 29%:71%; (2) basal vs. artificial sweetener, 60%:40%; (3) basal vs. combination of sucrose and artificial sweetener, 24%:76%; (4) sucrose vs. artificial sweetener, 72%:28%; (5) sucrose vs. combination of sucrose and artificial sweetener, 64%:36%; and (6) artificial sweetener vs. combination of sucrose and artificial sweetener, 34%:66%. These results demonstrate that pigs of this age prefer a ration that contains sucrose to a ration that contains no sucrose and to a ration containing a similar level of sweetness from the artificial sweetener source.

127. LYSINE SUPPLEMENTATION OF SORGHUM GRAIN-COTTONSEED MEAL RATION FOR GROWING-FATTENING PIGS. Fred Hale and Carl M. Lyman, *Texas A. and M. College, College Station.*

Swine feeding trials were conducted with cottonseed meal—grain sorghum rations supplemented with various levels of synthetic lysine and a commercial lysine feed

supplement. Two cottonseed meals, one of low protein quality (nitrogen solubility, 18.20%; lysine with free epsilon amino groups, 1.99% of protein) and another of relatively high protein quality (nitrogen solubility, 57.85%; lysine with free epsilon amino groups, 2.99% of protein) were used. Both meals were low (less than 0.04%) in free gossypol. In the case of the low quality CSM, lysine supplementation (0.6% of ration) increased the growth rate by 500%. In the case of the high protein quality cottonseed meal the increase in growth rate was 68%. The results indicate that cottonseed meals of average or less than average protein quality can be effectively used as the sole protein concentrate when supplemented with lysine. The amount of lysine required to produce excellent gains depended on the protein quality of the cottonseed meal. The pigs receiving the low quality cottonseed meal with lysine supplementation required 40% less feed per 100 pounds of grain than the group receiving the same ration without lysine supplementation. No indication of gossypol toxicity or other harmful effects were observed in any group.

128. EFFECT OF VITAMIN A DEFICIENCY ON THE ANTIBODY PRODUCING ABILITY OF SWINE. B. G. Harmon, E. R. Miller, D. E. Ullrey and J. A. Hoefer, *Michigan State University, East Lansing.*

Two trials were conducted. Baby pigs were placed on a synthetic milk diet devoid of vitamin A at 3 to 5 days of age. At 10 to 12 days of age the pigs were uniformly divided into two groups, the one group receiving a synthetic milk diet containing no vitamin A and the other group receiving a synthetic milk diet containing 1800 IU of vitamin A per lb. of solids. At about 4 weeks of age the pigs received the same diet in a dry form. At 8–9 weeks of age the pigs were put on a natural diet based on wheat, oats, and soybean oil meal with vitamin A supplementation to the appropriate lot. Blood serum levels of vitamin A were determined weekly from 4 weeks of age to the completion of the experiment. When the serum vitamin A level of the pigs on the vitamin A deficient diet had diminished to 10–15% mcg., all pigs in both lots began receiving a series of six daily injections of Salmonella pullorum antigen. Seven days following the last injection the pigs again were bled and the agglutination titer was determined. This test was made during the ninth, tenth and eleventh weeks. Pigs receiving vitamin A showed a greater response to Salmonella pullorum injections. Following a repletion period for the vitamin A deficient pigs the agglutination titer was redetermined.

129. SOME EFFECTS OF PELLETED COMPLETE RATIONS ON GROWTH, DIGESTIBILITY AND VOLATILE FATTY ACID ABSORPTION BY SHEEP. J. E. Haught, G. B. Thompson and W. H. Pfander, *University of Missouri, Columbia.*

Pelleted or ground rations of 70% alfalfa, 27% corn, 2.5% soybean oil meal and 0.5% salt were fed yearling wethers. Two equal lots of eight wethers were fed for 133 days at various levels ranging from submaintenance to *ad libitum* consumption. This was followed by a 5-week ration reversal trial. Differences in weight gains between the two lots were significant ($P<.05$) in favor of sheep fed the pelleted ration during the early part of the trial and during the ration reversal trial. The pellet-fed sheep consistently maintained a heavier average body weight. Two digestion trials were conducted with 10 mature wethers fed at maintenance and *ad libitum* feeding levels. The pelleting process significantly ($P<.01$) decreased the crude fiber content of the rations. A correspondingly significant ($P<.01$) decrease in the COD of fiber was found when the pellets were fed. Absorption of VFA's was studied in eight acute experiments. Absorption of VFA's was significantly correlated with rumen weight ($r=0.906$, $P<.01$) and with body weight ($r=0.828$, $P<.05$). No significant differences in VFA absorption or gross appearance of the rumens of sheep fed pelleted and un-

pelleted rations were found. In earlier studies, enlarged rumen papillae and more rapid VFA absorption resulted with a 50% concentrate ration self-fed to lambs as pellets compared to unpelleted forms.

130. APPLICATION OF THE EQUATION OF THE CURVE OF DIMINISHING INCREMENT TO SWINE NUTRITION. V. E. Headley, E. R. Miller and J. A. Hoefer, *Michigan State University, East Lansing.*

Two studies were conducted using live weight-feed consumption data from 280 baby pigs (birth to weaning) on a synthetic milk diet and from 1200 pigs (weaning to market) fed a typical ration of fixed composition in an attempt to determine if these data conformed to the equation of the curve of diminishing increment and thus apply equations derived from it. Live weight and feed consumption averages were calculated at equal time intervals (4-day intervals for baby pig and 2-week intervals for animals weaning to market). Constants for the equation of the curve of diminishing increment were calculated and adjusted by the statistical method of least squares. Application of the equation to baby pig data is limited since the live weight-feed consumption relationship was essentially linear. The equation conforms to the weaning to market data with a high degree of accuracy. Calculated values of cumulative feed consumption were in agreement with N.R.C. standards but calculated instantaneous efficiency deviated from N.R.C. standards in heavier weight animals. Cumulative maintenance requirement increased exponentially with increasing live weight. Instantaneous maintenance requirement increased linearly with increasing live weight when expressed as percent of instantaneous feed consumption, but exponentially when in terms of pounds of feed per day. The graphical solution of the live weight at which the pig-plus-feed cost per gain is the least gave a reasonable estimation of the live weight of the animal at which maximum returns are obtained.

131. IN VITRO LIPOLYSIS BY RUMEN INGESTA. F. D. Hill, J. H. Saylor, R. S. Allen and N. L. Jacobson, *Iowa State University, Ames.*

Various neutral fats, including C^{14}-labelled tripalmitin, were incubated *in vitro* with bovine rumen liquid at 38° C. with shaking. Percent hydrolysis of the triglycerides was determined by titration and/or by measurement of radioactivity. The increase in hydrolysis of soybean oil appeared to be linear for the first 24 hours and subsequently plateaued. Maximum hydrolysis occurred under environments of CO_2 or air; N_2 depressed the lipolysis. Fractionation by centrifugation indicated that the enzyme is associated primarily with the protozoa. Higher activity was observed in samples of ingesta taken in the morning and midafternoon before feeding; samples obtained after feeding and at night possessed a lower capacity for hydrolysis. Rumen liquid from animals grazing alfalfa possessed several times more lipase activity than ingesta from animals on dry feeds. Though large variations occurred, ingesta from animals more susceptible to bloat tended to have the highest lipolytic activity; 10 ml. of rumen liquid hydrolyzed as much as 96% of 0.5 gm. soybean oil in 24 hours. Taurocholate did not increase enzymatic activity. Procaine penicillin G, erythromycin, and tylosine (0.003% solutions) depressed lipolysis more than 50%. The same concentrations of streptomycin and chloramphenicol also were quite effective; inhibition by neomycin was almost nil. Mannose, in 0.5% solution, had marked inhibitory effect. Incubation of various esters (0.5 gm.) with 10 ml. rumen liquid under CO_2 for 24 hours resulted in hydrolysis of 94.9, 41.5, 60.7, 10.5, 10.7 and 8.3%, respectively, of soybean oil, ethyl laurate, ethyl oleate, and di-octyl, di-decyl, and di-dodecyl esters of tetrapropenylsuccinic acid.

132. EFFECT OF HEAT TREATMENT OF THE RATION, SELENIUM AND VITAMIN E ON THE INCIDENCE OF MUSCULAR DYSTROPHY IN THE LAMB. D. E. Hogue and R. G. Warner, *Cornell University, Ithaca, New York.*

A known, low selenium, dystrophogenic ration of mixed trefoil-grass hay and raw cull kidney beans was fed to 80 grade, pregnant ewes during the fall and winter of 1959–60. One month prepartum the ewes were assigned at random to five groups for the following treatments. (1) Control group—hay and cull bean basal, (2) Autoclaved basal ration (hay cooked 30 minutes at 250° F., beans cooked 15 minutes at 250° F. or 15 lb. steam pressure), (3) Ewes—basal ration, lambs—350 I.U. dl-alpha-tocopheryl acetate orally once weekly, (4) Ewes—basal ration, lambs—3.5 mg. Selenium as Na_2SeO_3 orally once weekly, (5) Ewes—basal ration plus 50 I.U. dl-alpha-tocopheryl acetate plus 1.0 mg. Selenium per day, lambs—no treatment. The experiment was concluded when the lambs averaged approximately 60 days of age. The incidence of diagnosed muscular dystrophy (stiff-lambs or white muscle) in the lambs of the five lots was 4 of 17, 0 of 19, 0 of 17, 0 of 15 and 0 of 14, respectively. The complete and equal protection afforded the lambs by cooked feeds, selenium and vitamin E indicates that dietary factors other than simple selenium and/or vitamin E deficiencies are important in muscular dystrophy in the lamb. The possible presence of a heat labile antagonist in the basal feeds is proposed.

133. EFFECTS OF IRON-DEXTRAN INJECTIONS ON SUCKLING LAMBS. R. C. Holz, T. W. Perry and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Two experiments were conducted to determine the effects of iron-dextran injections on lambs. Weight gains, hemoglobin levels, and livability were parameters compared. In addition, the hemoglobin level at birth, the hemoglobin pattern of suckling lambs, and the desirable normal hemoglobin levels of suckling lambs were determined. In experiment I, lambs were injected at about one week of age with 2 ml. of Armidexan (100 mg. per lamb). Weight gains for injected lambs were 14.65% greater than the controls. Hemoglobin levels rose following injection, while hemoglobin levels of control lambs fell. Differences in weight gains and hemoglobin levels were not significant. Ewe lambs from 160 ewes were used for experiment II. Treatments were (1) no iron injection, (2) 150 mg. of iron administered during the first 24 hours of life, and (3) 300 mg. of iron administered in two equal injections at 1 and 10 days of age. Weight gains for the treatments were 0.542, 0.565, and 0.583 lb. daily, respectively. These were not significantly different. Lambs receiving 300 mg. of iron suffered less than half the mortality of other groups. Average hemoglobin level of lambs less than 24 hours old was 14.17 $\pm$ 1.57 gm. %. More variation was found at birth than at any other age. Hemoglobin levels of all lambs dropped 1.4 gm. % during the first 3 days of life. Control lambs developed mild anemia. Iron-dextran significantly influenced hemoglobin levels ($P<.0005$). A desirable level of hemoglobin appeared to be 11.25 gm. %.

134. SWINE SELF-FEEDERS: A COMPARISON OF WASTAGE AND DESIGN. D. J. Horvath and K. C. Eiliott, *West Virginia University, Morgantown.*

Conduct of feeding trials disclosed problems due to feed wastage which prompted the authors to compare available swine feeders. To date, six models of commercially produced swine self-feeders have been studied to determine extent of feed wasted and the relation between design and control of waste. Feeders were mounted on platforms having expanded metal screens through which wasted feed could drop into collection pans. The following data were recorded: pigs' weight and gain, feed offered, and

feed wasted. Values for feed wastage varied from model to model and, to a lesser degree, between replicates. Extreme values for waste for the entire finishing period were 1% and 20% of all feed offered.

135. EFFECTS OF LYSINE ADDITIONS AND PELLETING UPON NUTRITIVE VALUE OF MILO FOR FINISHING SWINE. A. H. Jensen, D. E. Becker and S. W. Terrill, *University of Illinois, Urbana.*

One hundred and eighty-five pigs averaging 123 lb. were used in four experiments to evaluate milo fortified with vitamins, minerals, and antibiotics for finishing swine. In Experiment 1, 0.25% supplemental lysine proved superior to 1.0% of either condensed fish solubles or soybean oil meal in stimulating growth rate and feed efficiency. Neither 0.1% methionine nor 0.1% methionine plus 0.02% threonine showed a significant synergistic effect with lysine. In Experiment 2, pelleting and lysine addition were studied. With meal rations daily gains and feed per lb. of gain were, respectively, control 1.11, 5.43; 0.25% added lysine 1.55, 4.73. With pelleted rations, results were, control 1.64, 4.24; 0.25% added lysine 1.80, 3.81. In subsequent experiments all rations were pelleted. Experiment 3, rations were (1) 12% protein corn:soybean meal, (2) 12% protein milo:soybean meal, (3) milo, (4) milo plus 0.25% lysine, and (5) treatment 4 plus 0.10% methionine. Daily gains and feed per lb. of gain were (1) 1.79, 3.85; (2) 1.71, 3.83; (3) 1.16, 4.98; (4) 1.88, 3.60; (5) 1.78, 3.63. Treatment differences were significant ($P<0.05$) for both rate of gain and feed per lb. of gain. Experiment 4 was designed to determine the optimum level of supplemental lysine. Levels of added lysine with daily gain and feed per lb. of gain were, 0% lysine 1.51, 4.20; 0.08% lysine 1.70, 4.00; 0.16% lysine 1.94, 3.60; 0.24% lysine 1.89, 3.73; 0.32% lysine 1.94, 3.61. Lysine levels significantly affected rate of gain ($P<0.01$) and feed per lb. of gain ($P<0.05$). Representative animals from all treatments in Experiment 4 were slaughtered at approximately 200 lb. in weight.

136. VITAMIN E METABOLISM IN THE PIG. B. Connor Johnson and Peter Alaupović, *University of Illinois, Urbana.*

Five-Methyl-C^{14}-alpha tocopherol was given intraperitoneally to 175-pound pigs. The animals were killed 48 hours later and the livers taken for extraction. Solvent extraction followed by column chromatography of the extracts without saponification at any stage made possible the isolation of the metabolites of tocopherol. Paper chromatography proved the presence of two metabolites, both of which have been isolated in essentially pure form, and some of the chemical characteristics of these metabolites have been determined by means of ultraviolet and infrared spectrophotometry. Neither metabolite is identical with alpha-tocopheryl quinone, alpha-tocopheryl hydroquinone, trimethylphytyl benzoquinone, or the gamma lactone of trimethylhydroxymethylhexanyl benzoquinone.

137. EFFECT OF STARCH ON THE DIGESTION OF CELLULOSE *IN VITRO* AND *IN VIVO* BY RUMEN MICROORGANISMS. Ronald R. Johnson, K. el-Shazly and B. A. Dehority, *Ohio Agricultural Experiment Station, Wooster.*

In vitro and *in vivo* experiments were conducted to determine the nature of the inhibition of rumen microbial cellulose digestion in the presence of starch. When the starch:cellulose ratio was 1:1 or higher in the *in vitro* rumen fermentations, cellulose digestion was markedly or completely depressed. The inhibition did not appear to be due to a specific inhibitor or accumulation of end products such as formic or other acids produced by starch digesting microorganisms. Further experiments showed that the inhibition was due primarily to a competition for nutrients, the most

important one being nitrogen (urea). The inhibition was partially or completely alleviated by additional quantities of urea. Measurement of cellulose digestion rates *in vivo*, using filter paper in nylon bags, showed the same inhibition occurred *in vivo* when rations with ratios of 1:2 or higher of corn:hay were fed. This inhibition could also be partially alleviated by additional urea in the ration. The degree of inhibition and alleviation by urea both *in vivo* and *in vitro* depended on the ratio of starch: cellulose in the ration or medium. At high ratios of starch: cellulose both *in vivo* and *in vitro*, cellulose digestion was completely inhibited and could not be recovered by additional quantities of nitrogen.

138. TYLOSIN—A NEW ANTIBIOTIC GROWTH STIMULANT FOR SWINE. C. E. Jordan, W. P. Waitt and T. M. Means, *Eli Lilly and Company, Agricultural Research Center, Greenfield, Indiana.*

Tylosin is produced by a previously undescribed strain of *Streptomyces fradiae*, an actinomycete originally isolated from a soil sample from Thailand. The antimicrobial spectrum is essentially gram-positive, but it is also active against certain pleuro-pneumonia-like organisms, spirochetes, and large viruses. Five experiments involving 376 pigs were conducted to determine the efficacy of tylosin as a growth stimulant and to determine the optimum feeding level. Tylosin levels ranging from 10 to 100 gm. per ton of complete feed were tested. Growth rate was stimulated as much as 44% during the period from 15 to 40 lb. and up to 39% during the period from 25 to 40 lb. Gains were increased as much as 17% from 40 to 100 lb. liveweight. Growth response was obtained, but to a lesser degree (up to 9%) from 100 lb. to market weight. Feed efficiency was increased as much as 16% up to 40 lb. in weight and as much as 6% from 40 to 100 lb. liveweight. Generally, feed efficiency was not improved between 100 lb. and market weight. Under the conditions of these trials, the optimum feeding level of tylosin for growth stimulation was 40 gm. per ton of complete feed for pigs up to approximately 40 lb., 20 gm. per ton of complete feed from 40 to approximately 100 lb., and 10 gm. per ton of complete feed from 100 lb. to market weight.

139. DIGESTIBILITY OF HIGH ENERGY RATIONS BY DAIRY CATTLE. Herbert N. Jordan and Gerald M. Ward, *Colorado State University, Fort Collins.*

Identical twin Holstein cows were used in a series of three digestion trials using alfalfa, beet pulp, and a ration of half beet pulp and half alfalfa. Lactating Milking Shorthorn twins were used in a second series of digestion trials to determine the digestibility of rations containing low fat, and a ration containing either 10% tallow or 10% corn oil. Volatile fatty acid concentrations were determined on the three fat rations using Brown Swiss twins. Energy determinations and proximate analyses were made on feed and feces. The amount fed to each twin of a set was equal on a dry matter basis and the daily intake was constant through out each trial. The average digestion values for alfalfa, beet pulp, and half alfalfa and half beet pulp were; energy 65.25, 67.38 and 74.43% and TDN 62.25, 74.18 and 69.49%, respectively. In the second series the average digestion values for energy were 69.98, 71.12, and 67.42 and TDN were 71.49, 76.66 and 68.4%, respectively, for low fat, 10% tallow, and 10% corn oil rations. A higher concentration of rumen VFA and a higher A/P ratio was found with the low fat ration than with either the 10% tallow or 10% corn oil rations. A marked increase in milk fat percentage and a slight increase in milk production was obtained by feeding 10% tallow. However, the feeding of 10% corn oil decreased milk production, but did not change the milk fat percentage.

140. EFFECT OF CHEMOTHERAPEUTICS ON THE FECAL FLORA OF YOUNG PIGS. T. F. Kellogg, L. Y. Quinn, V. W. Hays, D. V. Catron and V. C. Speer, *Iowa State University, Ames.*

In two experiments involving 180 early weaned (2 weeks) baby pigs sampled three times over a four-week experimental period, the effects of eight different chemotherapeutics on the gains, feed/gain and fecal flora of pigs fed dry rations were studied. The first experiment compared diets containing chlortetracycline, oxytetracycline, penicillin, streptomycin, and a basal. The antibiotics were each added at the rate of 25 mg. of antibiotic base per lb. of ration. The observed 4-week gains and feed/gain were: 14.5, 1.78; 13.8, 1.76; 12.4, 1.77; 14.8, 1.80; 11.2, 2.06, respectively. Treatments significantly affected the fecal counts of total aerobes, total anaerobes, streptococci, and lactobacilli. The second experiment compared diets containing neomycin and bacitracin each at 25 mg. base/lb., 3-nitro-4-hydroxyphenyl arsonic acid (0.0025%), $CuSO_4$ (250 p.p.m. Cu) and a basal. The observed 4-week gains and feed/gain were: 10.5, 1.83; 9.7, 2.18; 9.2, 2.08; 11.9, 1.41; 9.5, 1.87, respectively. Total fecal counts of anaerobes, lactobacilli, and molds and yeast counts were all significantly affected by the treatments. Significant litter and pen effects were noted in the flora pattern for each experiment.

141. SERUM AND URINE MINERAL LEVELS IN THE BOVINE ASSOCIATED WITH DIHYDROTACHYSTEROL ADMINISTRATION. K. A. Kendall and K. E. Harshbarger, *University of Illinois, Urbana.*

Calcium and inorganic phosphorus levels and total reducing substances in the blood and urine were determined following single intra-muscular injections of 30 and 35 mg. of dihydrotachysterol in two non-lactating dairy cows. Observations on blood and urine were made at three- and six-hour intervals over a continuous 48-hour period following injection. Blood serum calcium rose from 9.7 mg. % to a maximum of 11.0 mg. % during the period, while blood serum inorganic phosphorus, after the first 12 hours, showed a slight but gradual decline of 0.4 mg. %. Urinary calcium concentration increased two to three times the preliminary level, with urine volumes remaining fairly constant. The urinary phosphorus excretion increased only slightly during the period, both in concentration and quantity. Total reducing substances in both blood and urine showed only slight variations and were well within normal range values.

142. FEEDING VALUE FOR FATTENING CATTLE OF CORN SILAGES TREATED TO INCREASE THEIR CONTENT OF ORGANIC ACIDS. Earle W. Klosterman, A. L. Moxon, Ronald R. Johnson, Harold W. Scott and Jack VanStavern, *Ohio Agricultural Experiment Station, Wooster.*

Treated and untreated whole plant and ground ear corn silages were stored in concrete stave silos. An addition of approximately 0.5% high calcium ground limestone and 0.5% urea to chopped whole plant corn at the time of ensiling increased the lactic acid content of the resultant silage by 78%, dry basis. Treated and untreated silages were fed with soybean oil meal, alfalfa hay, minerals and a half feed of dry, ground ear corn to triplicate lots of 14 Hereford heifer calves each for 224 days. Heifers fed the treated silage gained 11% faster and required 8.5% less feed per cwt. gain than those fed the untreated silage. In another experiment with different silages, one lot of 11 steers fed treated silage gained somewhat less than a similar lot fed untreated silage when no additional corn was included in the ration. When 8 lb. of ground ear corn were added to the daily ration, steers fed the treated silage gained slightly faster than those fed the untreated silage. Ear corn, 40.6% moisture, was artificially dried, ensiled without treatment or ensiled with 1% high calcium ground limestone and approximately 6% additional water. When fed, the

treated silage contained 125% more lactic acid than the control silage. The two silages and dry corn were fed to triplicate lots of seven Hereford steer calves each for 224 days. Steers fed the untreated silage required 10.4% less corn, dry basis, per cwt. gain than those fed the dry corn. Steers fed the treated silage gained 11.7% faster and required 7.4% less dry corn per cwt. gain than those fed the untreated silage. Carcass grades and dressing percentages were obtained for all cattle fed.

143. NUTRITIVE VALUE OF MIXED HAY FED AS THE SOLE RATION IN THE LONG, GROUND AND PELLETED FORMS. E. W. Klosterman, Gary E. Ricketts and R. R. Johnson, *Ohio Agricultural Experiment Station, Wooster.*

A steer feeding trial and a lamb digestion trial were conducted. The steer trial was divided into two parts. In the first part (98 days) an all roughage ration was self-fed. Steers fed pelleted hay made the most rapid gains, and, per hundredweight gain, required the least feed and had the lowest feed cost. In the second part (112 days) the steers were self-fed a mixture of 90% ground ear corn and 10% soybean oil meal in addition to the self-fed hay rations. The steers fed long hay made the most rapid gains and had the lowest feed cost per hundredweight gain. In the whole experiment, the steers fed pelleted hay had a highly significant increase in rate of gain. However, there was very little difference in the feed cost per hundredweight gain between the three rations. In the digestion trial chopped hay was used in addition to the three hay rations. Voluntary consumption of the rations was maintained throughout the trial. Pelleted hay was consumed in the largest amount and chopped hay in the least amount. The digestibility coefficients for organic matter, cellulose, crude fiber and calories were significantly higher for long hay than for chopped hay, and higher for chopped hay than for ground and pelleted hay.

144. EFFECT OF CERTAIN FEEDSTUFFS UPON THE DIGESTIBILITY OF ALFALFA-BROME SILAGE. O. E. Kolari, A. L. Harvey and M. E. Davison, *University of Minnesota, St. Paul.*

Digestibility studies with eight beef steer calves (approximate weight, 500 lb.) were conducted to determine the effect of feeding small amounts of certain feedstuffs upon the digestibility of rations composed mainly of alfalfa-brome silage. Rations for Latin square 1 consisted of 20 lb. alfalfa-brome silage with the following treatments: (1) 2 lb. corn; (2) 1½ lb. corn and ½ lb. alfalfa-brome hay; (3) 1½ lb. corn and ½ lb. dehydrated alfalfa meal; (4) 1½ lb. corn and ½ lb. molasses. Rations for Latin square 2 also consisted of 20 lb. alfalfa-brome silage with the following treatments: (5) 2 lb. corn; (6) 1.94 lb. corn and 0.06 lb. urea; (7) 1½ lb. corn and ½ lb. linseed oil meal; (8) 1½ lb. corn and ½ lb. dried distillers solubles. Calcium, phosphorus, trace mineralized salt and vitamin D were fed to meet NRC recommendations. Dry matter and fiber digestibilities were not significantly affected by treatments. Digestion coefficients ranged in value from 56.5 to 59.9 for dry matter and 49.5 to 54.9 for fiber. Digestibility values (percent) for protein and NFE, respectively, for the following treatments were: (1) 48.9, 69; (2) 51.0, 63.1; (3) 51.5, 65.3; (4) 43.6, 67.0; (5) 50.2, 68.9; (6) 59.6, 68.4; (7) 58.3, 67.9; (8) 54.6, 68.2. Significant differences between digestion coefficients existed for protein ($P<.05$; LSD, 4.39) and NFE ($P<.01$; LSD, 4.45) in Latin square 1. Differences in the digestion coefficients for protein were significant ($P<.01$; LSD, 2.78) in Latin square 2.

145. FEEDING VARYING AMOUNTS OF HAY WITH CORN SILAGE TO FATTENING BEEF CATTLE, O. E. Kolari, A. L. Harvey and J. C. Meiske, *University of Minnesota, St. Paul.*

Two trials were conducted in which four levels of alfalfa-brome hay were fed to fattening beef cattle: (1) no hay; (2) 2 lb. hay; (3) 4 lb. hay; (4) 6 lb. hay. Forty-

eight yearling steers were fed in trial 1 and 48 heifers in trial 2 for 69 and 106 days, respectively. Corn silage was fed to appetite and corn was fed at 6 lb. per head daily. The crude protein intake of the cattle was equalized with linseed oil meal between treatment groups. Average daily gains (lb.) and feed dry matter per lb. gain (lb.), respectively, of the four treatment groups during this high-forage phase of feeding in the steer trial were: (1) 2.62, 7.29; (2) 2.62, 7.08; (3) 2.58, 7.46; (4) 2.42, 8.00. Similar data for the heifer trial were, respectively: (1) 1.89, 6.97; (2) 1.88, 6.96; (3) 1.82, 7.37; (4) 1.61, 8.23. Results of both trials were quite similar. Feeding either 0, 2 or 4 lb. of hay with corn silage resulted in average weight gain and average efficiency of feed use data that were essentially similar. Results indicated that feeding 6 lb. hay yielded lower average daily gains and efficiency of feed use than the other three treatments. The difference in weight gain between trials was highly significant. However, because of variability of gains within treatments, the differences between treatment groups were not significant.

146. FEED EFFICIENCIES OF YOUNG RUMINANTS FED LOW-ROUGHAGE RATIONS. J. W. Lassiter, J. W. White, M. K. Cook, E. P. Warren and R. A. Long, *University of Georgia, Athens.*

Self feeding of low-roughage rations to calves and lambs in drylot has not been considered advisable because of costs and digestive disturbances. Information is not available, therefore, on feed conversion and gains of young ruminants fed such rations. Three trials involving 40 beef calves (rations I-VI) and 6 lambs (ration VII) were used to study the effect of group feeding low roughage, drylot rations upon feed efficiencies and average daily gains. Rations I, III and VII were roughage-free (other than 5% alfalfa meal), but all except III were fed to animals on straw bedding; II included a maximum of 1 lb. Coastal hay per head daily; IV and V included barley straw, free choice and VI had ground hay mixed into the ration. Calves on rations I and II were steers and heifers, respectively. Feed per pound gain includes the roughage eaten. Initial weights, final weights, ADG and feed required per pound gain for the seven rations were: I, 172, 407, 2.33, 3.57; II, 151, 339, 1.86, 4.22; III, 126, 206, 1.04, 3.57; IV, 150, 265, 1.50, 3.23; V, 139, 264, 1.64, 3.60; VI, 138, 256, 1.55, 4.29; and VII, 47, 99, 0.71, 4.25. In the earliest stages, feed required per pound gain was as low as 1.9 in lot VI (calves) and 1.3 in lot VII (lambs). Feed efficiencies and gains of these magnitudes suggest the possibilities of successful drylot feeding of young ruminants.

147. AMINO ACID METABOLISM BY RUMEN MICROORGANISMS. T. R. Lewis and R. S. Emery *Michigan State University, East Lansing.*

The amino acids tryptophan, serine, arginine, ornithine, aspartic acid, glutamic acid, lysine, cysteine, cystine, phenylalanine, and threonine were readily dissimilated when added individually to incubating rumen fluid or washed cells. The D and L forms of tryptophan and serine were both dissimilated. Tryptophan yielded indole and skatole. Arginine yielded ornithine, putrescine and deltaaminovaleric acid (DAVA). Lysine yielded cadaverine and DAVA whereas ornithine yielded DAVA. The dissimilation rates were more rapid and complete in rumen fluid studies than in washed cell suspensions. Penicillin at 3 units/milliliter did not inhibit any of the dissimilation. Tests for amine production from casein hydrolysate and individual amino acids at pH 6.5, 5.5 and 4.5 were negative, except for cadaverine and putrescine.

148. SPECIAL NUTRITIONAL SIGNIFICANCE OF SOLUBLE NITROGEN IN PROTEIN FEEDS CONSUMED BY RUMINANTS. Oran Little and Wise Burroughs, *Iowa State University, Ames.*

The soluble nitrogen content of several protein feeds was determined with rumen fluid, distilled water and dilute alkali as solvents. The results were evaluated with

respect to *in vitro* rumen cellulose digestion and as sources of nitrogen in lamb fattening rations. Heat treated soybean oil meal (110° C for 24 hours) and corn gluten meal were particularly low in soluble nitrogen, only slowly converted to ammonia by rumen microbial degradation and ineffective as nitrogen sources for *in vitro* cellulose digestion by washed suspensions of rumen microorganisms. Regular processed soybean oil meal, linseed meal, casein and soy protein were rapidly converted to ammonia and were effective sources of nitrogen for *in vitro* rumen cellulose digestion. Lambs fed low quality roughage rations containing either regularly processed or heated soybean oil meals at 7, 10 and 13% protein levels performed equally well. Both regular and heated soybean oil meals and linseed meal were similar in promoting growth when fed to lambs in semi-purified rations and were superior to corn gluten meal. Additions of lysine and methionine to corn gluten meal appeared to be of little value; however, the addition of urea to corn gluten meal markedly improved its value both in stimulating *in vitro* rumen cellulose digestion and in increasing lamb liveweight gains.

149. EFFECTS OF CHLORTETRACYCLINE AND TETRA ALKYLAMMONIUM STEARATE IN SHIPPING AND ADAPTATION STUDIES WITH CATTLE. R. M. Luther, L. B. Embry, F. W. Whetzal and J. K. Lewis, *South Dakota State College, College Station.*

Two 4-week feeding trials were conducted to test the value of chlortetracycline (Aureomycin) and tetra alkylammonium stearate (Dynafac), both at high levels, when fed to feeder cattle which had been subjected to stresses of shipping and handling. In Trial I a total of 237 feeder calves (av. lot wt. 350–400 lb.) were used at three outlying substations during the fall-winter months (1959). Aureomycin was fed in the protein supplement at the rate of 300 mg. per animal daily in drylot and on winter range grazing. The drylot calves were full-fed prairie hay. All calves were fed 4 lb. daily of a 20% protein supplement fortified with minerals and vitamin A. Pounds daily gain for control and Aureomycin, respectively, at the three stations were: drylot, 0.79, 1.06*; 0.98, 1.32; 1.38, 1.38; and for winter range grazing, 1.34, 1.67* for calves shipped in the 0.69, 1.52** for calves raised at the station. Trial II was conducted in the spring (1960) with 291 yearling steers that were divided into groups (A), (B), and (C) according to weight and time of arrival. Initial weights were 375, 549 and 509 lb., respectively. They were started on 20 lb. corn silage and full-fed the remainder of the trial. Two lb. soybean oil meal with minerals added was fed daily. Each group included a control, 250 mg. Aureomycin/head daily, 4 gm. Dynafac/head daily and 250 mg. Aureomycin and 4 gm. Dynafac/head daily. Pounds daily gain for groups and treatments respectively, were (A) 2.35, 2.72*, 2.40, 2.35; (B) 2.32, 2.87**, 2.21, 2.73**; and (C) 1.67, 2.32**, 2.40**, 1.53. Feed consumption was not reduced by antibiotic or chemobiotic supplementation. (*$P<.05$, **$P<.01$).

150. FACTORS AFFECTING SOYA-PROTEIN UTILIZATION BY YOUNG PIGS AND RATS. J. H. Maner, W. G. Pond and J. K. Loosli, *Cornell University, Ithaca, New York.*

Twenty-five 3-day-old baby pigs were used in a growth-metabolism trial to study the effects of two levels of methionine supplementation to a soya-protein (Drackett), simulated-milk diet and to compare casein and soya-protein as protein sources. Methionine was added to the soya basal at levels of 0%, 0.6% and 1.2% of the protein so that the finished milk contained 1.8% (soya-basal), 2.4% and 3.2% of the protein as methionine in lots 1, 2 and 3, respectively. All diets contained 28% protein, except diet 5 which contained 26.5% protein. The animals were control-fed the liquid simulated-milk diets four times per day and were housed individually in temperature-controlled metal brooders. The average weight gains for the 21-day

experimental period were as follows: Lot 1, 1313 gm.; Lot 2, 1558 gm.; Lot 3, 1521 gm.; Lot 4 (casein, 28% protein), 2013 gm.; and Lot 5 (casein, 26.5% protein), 2125 gm. Observations on rate of passage using ferric oxide as a marker, indicated that soya-protein diets passed through the G.I. tract in 14 to 24 hours, whereas casein diets required 36 to 48 hours. Measurements of the pH of stomach contents taken from 26 young pigs at slaughter or by stomach tube indicated that the pH is rarely less than 3.0 (av. of 38 measurements 3.5, range 1.8–5.4). Forty weanling rats were used in a 28-day growth trial to compare: casein, Drackett, Promine, and 44% protein soybean oil meal. All diets contained 10% protein and were eaten *ad libitum*. Average daily gain (gm.) and feed per gm. gain (gm.) were as follows: Casein, 2.42, 4.91; Drackett, 1.20, 9.36; Promine, 1.37, 8.44; and 44% protein soybean oil meal, 2.39, 5.48.

151.

152. THYROXINE AND TESTOSTERONE IMPLANTS FOR FATTENING LAMBS. J. K. Matsushima, A. S. Mukhtar, D. C. Clanton and L. C. Payne, *University of Nebraska, Lincoln.*

The effects of thyroxine and testosterone implants were compared, singly and in combination, on the feedlot performance, carcass grades, digestibility of nutrients, nitrogen balance, and histology of the thyroid glands. Twenty-eight western wether lambs were allotted to four treatments: (1) control; (2) subcutaneous injection of 25 mg. testosterone enanthate; (3) subcutaneous injection of 10 mg. sodium-L-thyroxine; and (4) a combination of 25 mg. testosterone and 10 mg. thyroxine. The ration consisted of ground shelled corn and chopped alfalfa hay in nearly equal proportions. During the 103-day feeding period, all three hormone treatments significantly increased the liveweight gains ($P<.05$). Feed efficiency and carcass grades were also improved; the greatest response was obtained from the combination of the hormone implants. Two metabolism trials (Trial I, 3 weeks post-hormone injection; Trial II, 9 weeks post-hormone injection) were conducted in conjunction with the feeding trial. The apparent digestibility of protein, fiber and energy was highest in the thyroxine implanted lambs, followed closely by the thyroxine-testosterone implanted lambs, in Trial I. However, in Trial II, the digestibility of these nutrients was highest in the testosterone and thyroxine-testosterone implanted lambs. Histological comparisons of the thyroid glands were made after the lambs were slaughtered. Differences were observed in the size and number of thyroid follicles due to the hormone treatments.

153. DIGESTIBLE ENERGY OF A STEER RATION SUPPLEMENTED WITH TRANQUILIZERS AND DIETHYLSTILBESTROL SINGLY AND IN COMBINATIONS. M. M. McCartor and B. A. Koch, *Kansas State University, Manhattan.*

Studies were conducted to determine whether two tranquilizers fed either singly or in combination with diethylstilbestrol (DES) would affect the performance of fattening steers. Tranquilizers fed were trifluomeprazine (TFM), 5.0 mg. per animal per day and hydroxyzine (HZ), 2.5 mg. per animal per day. Diethylstilbestrol was fed at 10 mg. per animal per day. Twenty-four steer calves weighing about 500 lb. each were randomly allotted into six treatment groups of four each, and fed individually twice daily from February 3, 1959, to November 24, 1959. During this period two digestion trials were conducted: the first during April, May and June; the second, during September, October and November. Treatment groups and average digestion coefficients of energy for the two digestion trials were: TFM plus DES,

78.99, 78.62; HZ, 81.01, 80.98; HZ plus DES, 80.45, 79.86; Control, 82.94, 80.83; DES, 80.152, 81.11; TFM, 79.15, 78.750. Statistically, no significant differences could be detected due to treatments, periods or interaction of treatments on periods. Nitrogen retention and total digestible nutrient values were also determined.

154. EFFECT OF PELLETING RATIONS OF DIFFERENT CONCENTRATE TO ROUGHAGE RATIOS FOR FATTENING LAMBS. W. H. McClure, F. S. McClaugherty, J. P. Fontenot, R. C. Carter and W. M. Mestanza, *Virginia Agricultural Experiment Station, Virginia Polytechnic Institute, Blacksburg.*

Two feeding trials with 159 lambs were conducted at two branch stations (Shenandoah Valley and Southwest Stations). At each station the design was a 2x4 factorial. Coarsely ground and finely ground and pelleted rations containing the following roughage to concentrate ratios were self-fed: 70:30; 55:45; 40:60; 25:75. Digestible protein, calcium and phosphorus were approximately equalized. The concentrate portion consisted of shelled corn, cottonseed meal and limestone. In the trial at the Southwest Station, in which the hay consisted of low quality pasture clippings, daily gain was increased 0.11 to 0.15 lb. ($P<.01$) when the rations containing the various ratios were pelleted. There was also an increase in feed efficiency. In this trial rate of gain increased ($P<.01$) with each decrease in the proportion of hay until the ratio reached 40% hay and 60% concentrate, whether the ration was fed ground or pelleted. During the trial at the Shenandoah Valley Station, in which orchard grass-alfalfa hay was used, pelleting the ration increased rate of gain ($P<.01$) when the ratio was 70:30 or 55:45, had no significant effect when the ratio was 40:60, and decreased gain ($P<.01$) when the ratio was 25:75. Maximum gains were obtained when the ratio was 40:60 for the ground rations and 55:45 for the pelleted rations. In both trials, the lots fed the high roughage rations (70:30) consistently had lower carcass grades and yields ($P<.01$). Pellet-fed lambs usually had significantly higher carcass yields than those fed ground feed. Pelleting had no effect on the incidence of rumen parakeratosis.

155. EFFECT OF PELLETING *PER SE* ON THE UTILIZATION OF MILO AND HIGH ROUGHAGE RATIONS BY STEER CALVES. J. E. McCroskey, L. S. Pope, D. F. Stephens and George Waller, *Oklahoma Agricultural Experiment Station, in Cooperation with Animal Husbandry Section—A.R.S., Stillwater.*

Fifty-four group-fed steers and 48 individually fed steers were fed 156 to 187 days. In trial I, calves were full-fed milo in a fattening ration in three forms, as follows: Lot 1—finely ground; Lot 2—finely ground and pelleted (3/8 inch pellet); Lot 3—reground pellets. In trials II and III, a 1:4 concentrate: roughage mixture containing equal parts of chopped alfalfa hay and cottonseed hulls was fed as follows: Lot 1—loose; Lot 2—pellets (3/8 inch); Lot 3—reground pellets and Lot 4—pellets limited to the intake of Lot 1. All calves except those in Lot 4 were self-fed. In trial I, finely ground milo resulted in faster gains, greater grain consumption and higher grading carcasses than ground and pelleted milo or reground pellets. Gains were about equal on the pellets and reground pellets but feed intake and feed required per cwt. gain were about 10% less on the pellets. Feed intakes on the finely ground milo and reground pellets were about equal. In trials II and III, rate of gain, feed intake and feed efficiency were greatest on the pelleted ration. Gains and feed efficiency of calves receiving reground pellets or a limited amount of pellets were greater than those on the loose ration. Results indicate that pelleting *per se* lowers the feeding value of a concentrate, but improves the nutritive value of high-roughage rations.

156. GRAIN PREFERENCE AND RESPONSE TO STILBESTROL IMPLANTS BY CREEP-FED BEEF CALVES. J. C. Meiske, A. L. Harvey and O. E. Kolari, *University of Minnesota, St. Paul.*

A group of 26 Hereford calves (18 steers and 8 heifers) and a group of 22 Angus calves (14 steers and 8 heifers) each had free-choice access to three rolled grains (shelled corn, barley and oats) in a creep feeder. Half the steer calves in each group were implanted with 12 mg. stilbestrol at the start of the trial on June 15, 1959. After 57 days, the two groups of calves were combined for the last 69 days of the creep-feeding period. The average age of the Hereford and Angus calves at the start of the trial was 56 and 70 days, respectively. Their average weight was about 150 lb. For the first 57 days the average daily intakes of corn, barley and oats, respectively, were: Hereford calves, 0.43, 0.40 and 0.01 lb.; Angus calves, 0.35, 0.48 and 0.05 lb. During the last 69 days the calves had average daily intakes of 2.72 lb. corn, 1.11 barley and 0.06 lb. oats. Average daily intakes for all calves during the 126-day trial was 1.67 lb. corn, 0.81 lb. barley, 0.05 lb. oats. Average daily gains for the steer calves were: control Hereford, 1.76 lb.; implanted Hereford, 1.94 lb.; control Angus, 1.77 lb.; implanted Angus, 1.89 lb. Subsequent average daily gains for a 152-day feedlot period following weaning for the control Hereford, implanted Hereford, control Angus and implanted Angus were 2.03, 2.16, 1.82 and 1.67 lb., respectively. Creep-fed calves preferred corn or barley over oats, and to a lesser extent, corn over barley. Implanting steer calves at 50–75 days of age resulted in 8.8% greater gains and ⅓ higher feeder grades at weaning with no consistent effect on post-weaning performance. The trial was repeated in 1960.

157. INFLUENCE OF FREQUENCY OF FEEDING PROTEIN SUPPLEMENT UPON DEVELOPMENT AND PRODUCTION OF RANGE BEEF FEMALES. A. A. Melton, J. H. Jones and J. K. Riggs, *Texas Agricultural Experiment Station, College Station.*

Two trials were conducted to study the influence of frequency of feeding protein supplement to range beef females. Three methods of feeding were used, viz., daily, three times weekly and twice weekly. In the first trial 30 head of choice quality weaned Hereford heifer calves were divided into three lots of 10 each. All lots received ground hegari stover and cottonseed hulls as a roughage free-choice and were hand-fed 14 lb. of cottonseed cake per animal per week for 111 days. The cottonseed cake was fed as follows: Lot 1—2 lb. daily; Lot 2—7 lb. twice weekly; Lot 3—14 lb. in three equal feedings, i.e., Monday, Wednesday and Friday. The average gain per animal for Lots 1, 2, 3 was 165 lb., 152 lb., 170 lb., respectively. These differences were not significant. In the second trial three groups of two-year-old bred heifers that calved were fed on the range 21 lb. of cottonseed cake weekly per animal as described above for 116 days. The animals were rotated in the pastures every two weeks. Feeding groups 1, 2 and 3 consisted of 28, 29 and 27 animals, respectively. The average loss in pounds per animal was as follows: daily fed, 78 lb.; twice weekly fed, 73 lb.; and, three times weekly fed 58 lb. These differences were not significant.

158. A PROPOSED METHOD FOR REMOVING SOURCES OF ERROR IN STEER EXPERIMENTS. J. H. Meyer, G. P. Lofgreen and W. N. Garrett, *University of California, Davis.*

Weight gain has long been one of the most commonly used criteria of steer response; but is weight gain consistent enough composition to be a sufficiently reliable measurement? Data from a series of 11 experiments with beef steers from which data are available on initial and final liveweight, carcass weight, carcass grade and

carcass specific gravity were used to develop a proposal for reducing errors in beef cattle experiments involving liveweight gains. The carcass as an experimental measurement corrected the effect of this variation because of a lower mean square for error in an analysis of covariance than with weight gain or final weight. Variation still remained in caloric and protein content but carcass specific gravity was used to predict carcass composition. Equations were then developed to correct the carcass to equal caloric content and adjust it in an analysis of covariance to equal initial weight. This corrected carcass, equivalent to one containing 17.3% protein, 20% fat and 1297 kcal. per lb., was a more reliable measure of animal performance than weight gain in combination with dressing percent and carcass grade. An analysis of covariance with randomization of the animals to the treatments was more efficient than covariance with balancing of the treatments to equal beginning weights or an analysis of variance with blocking on initial weight.

159. CALCIUM REQUIREMENT OF THE BABY PIG. E. R. Miller, D. E. Ullrey, C. L. Zutaut, D. A. Schmidt, E. A. Alexander, B. V. Baltzer, J. A. Hoefer and R. W. Luecke, *Michigan State University, East Lansing.*

Forty baby pigs receiving a synthetic milk diet were used in two trials to determine their calcium requirement. Levels of 0, 0.4, 0.6, 0.8, 1.0, 1.2 and 1.6% calcium were studied with the phosphorus level held constant at 0.5%. An analysis of the growth and feed consumption data indicate that 0.6% calcium supports maximum growth and feed efficiency. Data obtained on levels of serum calcium, serum phosphorus, serum alkaline phosphatase, and blood clotting time substantiate this indication. However, when a more nearly total measurement of the pig's well-being is considered, including data obtained from analyses of humeral ash, calcium and phosphorus, specific gravity of rib or femur, and breaking strength of femur, the minimum calcium requirement is not less than 0.8%. Pigs receiving no calcium exhibited classical clinical and subclinical symptoms including severe rickets, tetanic convulsions, increased blood clotting time and increased heart repolarization time. Bones were extremely soft, weak and porous with greatly decreased percentages of calcium, phosphorus and total ash. Serum calcium level was considerably reduced and serum alkaline phosphatase greatly increased in these animals.

160. EFFECT OF NUMBER OF CHOICES OF FEEDS OFFERED ON THE RESULTS OF CAFETERIA STUDIES WITH CALVES. W. J. Miller and C. M. Clifton, *University of Georgia, Athens.*

Forty-one calves were utilized to study the effect of number of choices on the relative amounts of each feed chosen. During the first year, seven trios of calves were used in which each calf was offered one of the following combinations of choices of feeds each week for nine weeks; (1) one container each of feeds A and B, (2) two containers of A and one of B, and (3) one container of A and two of B. Initially, one calf of each trio was assigned to receive each of the possible choices and rotated to a new combination of choices each week for three cycles in a Latin-square design. The second year, five groups of four calves each were employed in which two calves were offered choices (2) and (3) for one week each in sequence for four cycles. The other pair of calves received the same choices in reverse sequence. In each of the 12 trials the A and B feeds represented different pairs of calf starters or hays. The following results were obtained. When two choices of the same feed were offered, the calves consumed more than but not twice as much as when only one choice was available. Both of these aspects were highly significant by the chi-square test. These data are interpreted to indicate that, when more than two choices are available in a cafeteria study, the results are subject to error. Thus, the values obtained may not be reliable.

161. STUDIES ON THE FERMENTATION OF STARCH BY RUMEN MICRO-ORGANISMS *IN VITRO*. John E. Moore, Ronald R. Johnson and Burk A. Dehority, *Ohio Agricultural Experiment Station, Wooster.*

An all-glass artificial rumen system was used to study the fermentation of pure-food powdered corn starch by rumen bacteria obtained from four fistulated sheep fed a ration of 3 parts corn and 1 part hay. Differential centrifugation studies showed that the fraction of organisms sedimented between 250 and 3000 x G were representative of the organisms in strained rumen juice both on the basis of gram stain morphology and extent of starch fermentation. The extent of starch fermentation was evaluated by analysis for residual carbohydrate (anthrone colorimetric technique) and by the production of volatile fatty acids. At 6, 12 and 24 hours of fermentation, the milliequivalents of total volatile fatty acids produced per gram of starch fermented averaged 8.37 $\pm$ 0.85. Autoclaved rumen fluid enhanced starch fermentation at 6 hours but not at 9 hours. Biotin and p-amino-benzoic acid did not replace autoclaved rumen fluid in this respect. The optimum pH for maximum rate of fermentation ranged from pH 6.7–6.9. Gross morphological examination indicated that the mixed cultures used as inoculum were maintained as long as substrate remained non-limiting. These examinations indicated that certain types of bacteria were generally found in mixed cultures associated with high starch fermentative activity: gram positive crescent shaped rods, diplococci and diplorods; and, gram negative diplorods, diplococci and large irregular rods.

162. POTEIN-ENERGY RATIOS FOR BARROWS AND GILTS MARKETED AT 145 AND 195 POUNDS. R. Mulholland, E. S. Erwin and R. S. Gordon, *Monsanto Chemical Company.*

Weanling pigs (224) were allotted on the basis of weight to a 2^4 factorial type study that involved dietary protein and fat percent as well as sex and market weight. When the protein was increased from 14% to 28%, daily gains were reduced 0.19 lb. Added fat did not alter growth rate but reduced feed consumption and consequently improved feed utilization. No protein-fat interactions were found. The data suggest that productive energy value of feedstuffs used for poultry is not the same for swine. Barrows grew significantly faster than gilts, and, as would be expected, pigs marketed at 195 lb. grew faster than those slaughtered at lighter weight. Lean cuts with more carcass fat were less in barrows and in pigs marketed at the heavier weight. High protein diets resulted in leaner carcasses at both market weights; whereas, tallow feed produced a fatter carcass with less lean cuts. When all carcass measures were correlated to one another, hams were better related to total lean cuts than any other measurement. The estimation of lean percent from a grid photograph of the ham-end of the loin cut was closely related (r=0.84) to total lean cuts.

163. BIOCHEMICAL AND PHYSIOLOGICAL CHANGES OCCURRING WITH HYPOVITAMINOSIS A IN PIGS. Eldon C. Nelson, Burk A. Dehority, Howard S. Teague, Vance L. Sanger and William D. Pounden, *Ohio Agricultural Experiment Station, Wooster.*

Thirteen purebred Yorkshire pigs three weeks of age were placed on a purified diet deficient in vitamin A, until their blood plasma vitamin A concentrations were $\leq 7\gamma\%$. Cerebrospinal fluid pressures were determined and the pigs were randomly assigned to one of four levels of vitamin A: 2, 4, 8 or 16γ of vitamin A per pound live weight per day. The basal diet was fed at the rate of 0.04% per pound live weight per day at the start of the repletion period with the total daily feed increased 0.3 pound per day at the end of each successive seven-day period. Terminal cerebrospinal fluid pressure and blood plasma vitamin A concentrations were determined

at the end of 78 ± 1 days on an assigned level of vitamin A. The animals were then slaughtered and some of the constitutents of blood serum cerebrospinal fluid and aqueous humor were determined in addition to a histopathological examination of various tissues including the eye and parotid gland and duct. Cerebrospinal fluid pressure decreased while blood plasma and liver vitamin A concentrations increased with an increase in vitamin A intake. Terminal cerebrospinal fluid pressures of the pigs on 16γ vitamin A per pound live weight per day were somewhat below previously reported values for apparently normal pigs. Serum potassium increased significantly with vitamin A intake. No changes were observed in the concentration of the other fluid constituents studied. Histopathological examination indicated no consistent changes relative to vitamin A intake. The minimum vitamin A requirement for the pigs in this study would appear to be somewhere between 8 and 16γ per pound live weight per day.

164. COMPARISON OF DIFFERENT SUPPLEMENTAL ENZYMES WITH AND WITHOUT DIETHYLSTILBESTROL FOR FATTENING STEERS. LeRoy F. Nelson and Damon V. Catron, *Walnut Grove Products Co., Inc., Atlantic, Iowa.*

Eight enzyme experiments have been conducted with 582 steers. In one trial, 72 head of 800-lb. steers were fed a corn-alfalfa hay ration for 168 days. They were allotted into 12 lots to compare four enzymes, the relationship of enzymes to diethylstilbestrol (DES) and enzyme levels in fattening rations. All enzymes resulted in improved gains and feed conversion when fed with DES, except for two enzymes fed at reduced levels, only one improved gains without DES. Increased gains from enzymes (0.29 lb. per day) nearly equalled that of DES (0.33 lb. per day) over the controls. Treatments, enzyme levels per ton (in meal supplement fed at 1 lb. per head daily), daily gains and F/G were: Control 2.06, 1045; DES 2.39, 926; Agrozyme 10 lb. 2.35, 912; Agrozyme 15 lb. 2.06, 1013; Agrozyme 15 + DES 2.44, 882; Zymo-Pabst 10 lb. 2.29, 949; Zymo-Pabst 15 lb. 2.01, 1049; Zymo-Pabst 15 + DES 2.68, 855; Rhozyme B6 and Rhozyme H39 8.1 lb. 2.05, 1059; Rhozyme + DES 2.83, 816; Takamine HT550F 10 lb. 2.18, 981; and Takamine + DES 2.78, 823. Results of another test involving 36 steers were: Control 2.64, 831; DES 2.71, 823; Zymo-Pabst 15 lb. 2.51, 885; Zymo-Pabst 15 + DES 3.07, 801; Zymo-Pabst 15 + 1 lb. soybean meal to increase protein level 2.22, 968; Zymo-Pabst 15 + DES + 1 lb. soybean meal 3.10, 783. Extra protein had no effect on enzyme response in this test. The presence of DES and level of enzyme influenced degree of enzyme response.

165.

166. VALUE OF UNEXTRACTED SOYBEAN MEAL FOR GROWING-FINISHING SWINE. W. F. Nickelson, D. E. Becker, A. H. Jensen and S. W. Terrill, *University of Illinois, Urbana.*

Two trials involving 96 weanling pigs were conducted to study the value of unextracted soybean meal (A) vs. regular soybean meal (B). In the first trial protein quality was studied by feeding soybean meals as the sole or supplemental source of protein in diets containing 16% crude protein. Results in average daily gain and gain/feed ratio were: Lot 1 (A, sole protein), 0.91 and 0.379; Lot 2 (B, 50% protein, sole protein fed isocaloric with Lot 1), 1.20 and 0.424; Lot 3 (corn-B), 1.15 and 0.321; Lot 4 (corn-A), 1.29 and 0.360; Lot 5 (corn plus one-half of supplemental protein as each meal), 1.22 and 0.350; Lot 6 (corn-B fed isocaloric with Lot 4), 1.40 and 0.365, respectively. In Trial 2 pigs were individually fed the meals as sole sources of protein in diets containing 10% crude protein. Results in average daily gain and gain/feed ratio were: Lot 1 (A), 1.18 and 0.360; Lot 2 (B, fed isocaloric with Lot 1), 1.25 and 0.368; Lot 3 (B, plus 0.1% dl methionine), 1.46 and 0.392; Lot 4 (A, plus

0.1% dl methionine), 1.31 and 0.386, respectively. In addition, the meals were compared as supplemental sources of protein with corn in 16% protein diets. Results of Lot 5 (B) were: 1.37 and 0.346, and Lot 6 (A), 1.40 and 0.347, respectively. Statistical analysis revealed a highly significant difference ($P<.01$) in the average daily gains of Lots 1 and 2 in Trial 1 and a significant difference ($P<.05$) between Lots 1 and 3 of Trial 2. Carcass analyses indicated no statistically significant differences in pigs fed the two meals.

167. SOME EFFECTS OF PHYTIC ACID ON ZINC AVAILABILITY AND PHYSIOLOGY IN SWINE. D. Oberleas, M. E Muhrer and B. L. O'Dell, *University of Missouri, Columbia.*

Weanling pigs were fed basal diets based on casein (15% protein and 14 mg./kg. Zn) and soybean meal (15% protein and 25 mg./kg. Zn). Two 6-week trials were run and three variables were tested. The basal, calcium content, the phytic acid and Zn added are indicated in parenthesis for each diet. The average daily gain and feed efficiencies for Expt I were as follows: Lot 1 (Casein, 1.5%, 0, 0) 1.21, 2.43; Lot 2 (Soybean meal, 1.5%, 0, 0) 0.31, 4.51; Lot 3 (Casein, 1.5%, 1%, 0) 0.64, 3.14; Lot 4 (Casein, 1.5%, 1%, 100 mg./kg.) 1.10, 2.52; Lot 5 (Soybean meal, 1.5%, 1%, 0) 0.18, 7.62. For Expt II they were as follows: Lot 1 (Casein, 1.5%, 0, 0) 1.66, 3.28; Lot 2 (Casein, 0.8%, 0, 0) 1.54, 2.72; Lot 3 (Casein, 1.5%, 2%, 0) 0.35, 7.52; Lot 4 (Casein, 0.8%, 2%, 0) 0.46, 5.28; Lot 5 (Casein, 1.5%, 2%, 100 mg./kg.) 1.55, 2.65. Visual and histological analyses indicated that pigs receiving soybean meal basal developed parakeratosis but those receiving casein protein did not except when phytic acid was added. Serum alkaline phosphatase values were depressed when pigs were fed phytic acid. Zinc supplementation at 100 mg./kg. prevented the effects of added phytic acid. These data indicate that parakeratosis can be produced on a diet composed of animal protein if phytic acid is added at either low or high levels of dietary calcium.

168. EFFECTS OF NITRITE CONTAINING RATIONS IN PRODUCING VITAMIN A AND VITAMIN E DEFICIENCIES IN RATS. B. L. O'Dell, Zuhal Erek, Laura Flynn, G. B. Garner and M. E. Muhrer, *University of Missouri, Columbia.*

To evaluate under controlled conditions the field reports of avitaminosis A as a part of the nitrate toxicity syndrome, two groups of 12 weanling rats were used. Group I received a vitamin A deficient basal diet and group II received the basal diet plus 0.3% potassium nitrite. A period of 6 to 8 weeks was required for depletion. At this time xerophthalmia was evident in group II and growth in both groups had stopped. Rats in group I grew more rapidly than those of group II. Liver vitamin A analysis correlated with the growth data of the two rats sacrificed in each group. Each group was then divided into sub groups (1A, 1B and IIA and IIB). Sub groups A received the basal plus B-carotene (1 mg./100 gm.) and sub-groups B received the basal plus carotene and 0.3 percent nitrite. As in the first period, growth was depressed by potassium nitrite. After 4 weeks with carotene added (10 weeks from start of depletion) rats of group II showed a dystrophy typical of vitamin E deficiency. Not only did nitrite cause a more rapid depletion of vitamin A but it precipitated a vitamin E deficiency on a diet normally adequate in vitamin E (5 mg./100 gm.). Further proof of the vitamin E deficiency was shown by the improvement of appetite and muscular coordination when vitamin E concentrate was given to the rats in group II.

169. FREE AMINO ACID AND NPN LEVELS IN THE BLOOD AND MUSCLE OF BEEF CATTLE AS INFLUENCED BY STILBESTROL AND PROTEIN INTAKE. M. L. Ogilvie, R. W. Bray, E. R. Hauser and W. G. Hoekstra, *University of Wisconsin, Madison.*

In trial 1, eight steers per lot were fed a basal ration consisting of ground hay, oats and corn. Treatment per lot was: I, basal ration; II, basal ration plus 30 mg. stilbestrol/head/day; III, basal ration plus 2 lb. soybean oil meal (SBOM)/head/day; and, IV, basal ration plus stilbestrol plus SBOM. Blood samples were taken before and after a 20-hour fast at 0, 30, and 60 days during a 70-day feeding period. Average daily gain by lot was: I, 1.86 lb.; II, 2.48 lb.; III, 1.69 lb.; IV, 2.50 lb. Neither level of protein nor stilbestrol affected the total free amino acid content of the whole blood from these steers. The NPN level in the blood was not consistently altered, nor was the concentration of individual plasma free amino acids significantly altered by protein intake or stilbestrol. In trial 2, 32 heifers were ovariectomized three weeks prior to treatment. Lot I, control; Lot II, 30 mg. stilbestrol/head/day. Four heifers from each lot were slaughtered at 24 hours, 72 hours, 8 days, and 15 days after initiation of the experiment. Stilbestrol did not alter the total amino acid content of the plasma or of tissue from the *Longissimus dorsi* muscle, nor was the percent moisture of the muscle affected by treatment. Mean uterine weights were increased by stilbestrol treatment as was percent moisture of the uterus. The concentration of free amino acids within the uterus of ovariectomized heifers was altered by stilbestrol and this effect was apparent at least as early as 72 hours after oral administration of the synthetic hormone.

170. EFFECTS OF ESTROGENIC ACTIVITY IN ALFALFA ON GROWING LAMBS. J. E. Oldfield, C. W. Fox and E. M. Bickoff, *Oregon State College, Corvallis, and Western Utilization and Development Division, U.S.D.A.A.R.S., Albany, California.*

Two samples of dehydrated alfalfa meal were obtained which on mouse assay, showed potencies of 119 and 22 mg. coumestrol per kg. These meals were incorporated in pellets of the following percentage composition: alfalfa meal 65, ground barley 25, cane molasses 10, and were fed *ad lib.* to two groups of growing lambs of mixed sexes. The wether lambs gained significantly faster, the ewe lambs significantly slower when fed the high estrogen meal. Effect of the high estrogen meal in promoting vulval and udder development in the ewe lambs was noticeable after about 3 weeks on test. Federal grades at slaughter indicated little difference in the lambs on high and low estrogen meals, there being nine choice, one good versus eight choice and two good, respectively. Chilled carcass weights averaged 50.6% and 51.9%, respectively, of live weights from lambs fed high- and low-estrogen rations. Chemical analyses for ether-extractable fat and crude protein did not reveal significant differences in the loin eye muscle of lambs from the two groups, although there was a trend toward greater fatness in the high estrogen-fed group. Organoleptic tests conducted by a trained taste panel showed significant differences in tenderness, juiciness and texture between the two treatments—all in favor of the high estrogen-fed lambs.

171. EFFECT OF PROTEIN:ENERGY RATIOS ON THE PERFORMANCE AND CARCASS QUALITY OF FATTENING LAMBS. R. H. Olsen, R. G. Holleman, D. L. Staheli and L. H. Horn, *Swift & Company, Chicago, Illinois.*

A fattening trial was conducted with 217 California genuine lambs allotted to four treatments consisting of two rations (standard energy and high energy), which contained approximately 650 and 700 Kcal. per lb. of feed, respectively; and, two

levels of protein (12 and 14%). Basic feed ingredients were corn, alfalfa hay, molasses, and soybean oil meal. Average daily gains were: standard energy—12% protein 0.54 lb.; standard energy—14% protein 0.56 lb.; high energy—12% protein 0.50 lb.; and high energy—14% protein 0.59 lb. Feed efficiencies and carcass yields were 8.48 lb., 52.9%; 8.10 lb., 52.7%; 9.22 lb., 52.4%; and, 7.15 lb., 53.0%, respectively. In a second experiment, 277 Texas old-crop lambs were subjected to the same treatments. Average daily gains were 0.56 lb., 0.59 lb., 0.58 lb., and 0.63 lb., respectively. Corresponding feed efficiencies and carcass yields were 8.15 lb., 53.0%; 7.74 lb., 52.8%; 7.49 lb., 53.1%; and, 7.21 lb., 52.4%. There were no differences in carcass grades in either experiment. The incidence of soft, oily and bronze colored carcasses tended to be higher among lambs fed high energy rations in both experiments.

172. BEHAVIOR PATTERNS OF CALVES WHEN FED A MILK REPLACER MECHANICALLY. W. A. Olson and J. B. Williams, *University of Minnesota, St. Paul.*

Calves, 4 to 65 days of age, were observed for 30 individual 48-hour periods to determine behavior patterns when dairy calves are exposed to a continuous supply of warm liquid milk replacer (Nursette), hay and grain supplement, and water. The animals, 8 to 12 in a group, were housed in continuously lighted pens bedded with wood shavings. The observations recorded in 5-minute increments were: amount and frequency of milk replacer feeding, frequency of water and supplement consumption, time standing, and occurrence of rumination. Liquid milk replacer consumption varied from 3 to 30 lb. per day and was generally related to age. Milk replacer consumption became more regular as the calves increased in age, with most older calves consuming liquid feed every 3 hours. The calves consumed grain and hay supplement from 3 to 35 times per day and drank water from zero to 7 times per day. The calves were in a standing position an average of 6.25 + 1.35 hours per day. Calves as young as 11 days of age occasionally ruminated, while one calf 19 days of age ruminated for 4 hours per day. All calves were ruminating before 3 weeks of age.

173. EFFECT OF GROUND POLYETHYLENE, CRYSTALLINE AMINO ACIDS AND DIETHYLSTILBESTROL ON GAINS OF SHEEP FED A PURIFIED DIET. Robert Oltjen, Robert Sirny and Allen D. Tillman, *Oklahoma State University, Stillwater.*

Experiments have been designed to obtain a suitable purified diet for ruminants. Previous results indicated that an alkaline mineral mixture (J. Animal Sci. 18:1522) improved gains and feed efficiency. In the present experiment, the effect was studied of adding either 4% ground polyethylene or 0.4% DL-methionine to a urea basal ration of the following percentage composition: corn starch, 24.1; corn sugar, 24.1; corn oil, 1.0; Solkafloc, 40.0; Chlorine Cl, 0.1; minerals, 6.5; urea, 4.2; and vitamin A and D. Drackett C-1 protein was fed isonitrogenous with urea as a positive control. Twenty 70-lb. yearling sheep, five per treatment, were individually fed during this 54-day experiment. Daily gains and feed efficiencies were: urea, 0.21, 10.8; urea plus polyethylene, 0.24, 10.2; urea plus methionine, 0.28, 11.0; and Drackett, 0.39, 6.8. Daily gain and feed efficiency of Drackett were different ($P<.01$) from the other treatments. In the second experiment, five individually fed lambs, weighing about 48 lb., were used per treatment in isonitrogenous and isocaloric rations to study the effect of various adjuncts on the urea basal ration during a 50-day trial. Rations, daily gains and feed efficiencies were: urea basal ration, 0.28, 9.1; 1 mg. diethylstilbestrol per pound of ration, 0.28, 8.7; 0.2% DL-methionine, 0.26, 9.3; 0.2% L-lysine monohydrochloride 0.28, 8.8; 0.2% DL-alanine, 0.33, 7.4; 1 mg. diethylstilbestrol per pound of ration plus 0.2% DL-methionine, 0.30, 7.6. Differences in average daily gains or feed efficiencies were not significant.

174. GAIN, CARCASS, AND LIVER RESPONSE OF FEEDER LAMBS TO HORMONE IMPLANTS. J. W. Oxley, R. C. Thompson and C. J. Kercher, *University of Wyoming, Laramie.*

One hundred thirty wether lambs averaging 85 lb. and having grazed on beet tops, alfalfa and grain stubbles were randomly divided into six treatment groups of 21–22 head each in late December, 1959. Group I served as controls; group II, 3 mg. diethylstilbestrol (DES); group III, 6 mg. DES; group IV, Synovex-L (25 mg. progesterone and 2.5 mg. estradiol benzoate); group V, ¼ dose Synovex-H (50 mg. testosterone propionate and 5.0 mg. estradiol benzoate); group VI, testosterone enanthate (10 mg. per 0.21 cc.). All hormones were administered subcutaneously at the base of the ear when the lambs went into the feedlot. During the subsequent 67-day finishing period the lambs ate ground alfalfa hay *ad libitum* and were hand-fed an average daily ration of 0.5 lb. dried beet pulp and 2.0 lb. shelled corn. Average daily gains in pounds were (I) 0.44, (II) 0.63, (III) 0.67, (IV) 0.63, (V) 0.69, (VI) 0.50. The gains of lambs in all groups except group VI were significantly different ($P<0.01$) from those of the non-implanted lambs (group I). Carcass grades were unchanged by 3 mg. DES, slightly reduced by 6 mg. DES, Synovex-L and testosterone enanthate, and appreciably lowered by ¼ dose of Synovex-H. The percentage yields were (I) 49.5, (II) 48.9, (III) 48.6, (IV) 47.6, (V) 47.9, (VI) 49.3. No adverse side effects were observed during the feeding period. There were no significant differences in the uterine response of mice fed liver tissue from the control or implanted lambs.

175. EFFECTS OF DIETARY SODIUM CITRATE UPON FATTENING LAMBS. L. V. Packett, G. A. Butcher and J. R. Fordham, *Purdue University, Lafayette, Indiana.*

Ninety-two lambs were divided into four lots of 23 and self-fed a mixed diet known to produce a high incidence of urinary calculi (Proc. Soc. Exp. Biol. Med. 97:860, 1958). The group treatments followed by average daily gain and feed required per lb. gain were as follows: I, basal-meal diet, 0.37, 8.43; II, basal-pelleted diet, 0.34, 9.71; III, basal pelleted-citrate 0.50, 7.50; IV, basal, pelleted-oxytetracycline (10 mg./lb.) 0.46, 8.09. Salt and water were available *ad libitum*. The addition of purified sodium citrate (equivalent to 1.63% citric acid) to the diet (Group III) produced 47% increase in gain ($P<0.01$). The gain enhancement was greatest during the initial period, but gains were continuously greater throughout the experiment. Feed efficiency was increased 23%. Feed consumption was increased 23% for the first 50 days and 11% for the entire experiment. Salt intake was increased 11%. Water consumption was increased 40% and urine output was increased 95%. Lambs receiving sodium citrate excreted urine of lower specific gravity and slightly higher pH. Average carcass grades and dressing percent were higher in lambs receiving sodium citrate. oxytetracycline supplementation (Group IV) increased gain and feed efficiency.

176. LEVELS OF SUPPLEMENTAL VITAMIN A FOR FATTENING BEEF STEERS. T. W. Perry, W. M. Beeson and R. C. Holz, *Purdue University, Lafayette, Indiana.*

Cattle rations composed of natural feedstuffs contain no vitamin A *per se;* therefore, cattle must depend upon natural dietary precursors for their source of vitamin A. Seventy-two yearling steers were assigned to 6 lots of 12 each and fed a fattening ration of 88% ground ear corn; 11% soybean oil meal; 0.7% steamed bonemeal; and 0.3% cobalt-salt in an experiment designed to show the value of various levels of added vitamin A. The supplemental levels of vitamin A fed per head

daily in the respective six lots were: 0, 2000, 4000, 8000, 16000, 32000 International Units. Daily feed consumption tended to parallel increased levels of supplemental vitamin A (control, 18.9 lb. feed per head daily vs. 20.3 lb. feed for steers administered 32000 I.U. of vitamin A per day). Daily gain for the first 84 days did not necessarily follow this pattern although cattle in the highest vitamin A supplemented lot gained 2.33 lb. per day as compared to 1.89 lb. for the control lot. Plasma beta carotene levels appeared to be inversely related to level of vitamin A supplementation. Plasma vitamin A level reflected the level of supplemental vitamin A in the ration (control lot—plasma vitamin A, 30.2 mcg./100 ml.; 2000 added vitamin A, 33.4 mcg.; 4000 added A, 29.4 mcg.; 8000 A, 37.1 mcg.; 16000 A, 51.5 mcg.; 32000 A, 56.6 mcg.

177. LOW VS. HIGH MOISTURE SHELLED CORN WITH AND WITHOUT ENZYMES AND STILBESTROL FOR FATTENING STEERS. T. W. Perry, D. D. Cope and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Eight lots of 10 beef steers each were fed a fattening ration of a full feed of shelled corn, 2 lb. supplement, limited corn silage (15 lb.) and free choice minerals. In the factorial design, four lots were fed regular shelled corn (19.5% water) and four lots were fed high-moistrue ensiled shelled corn (29.7% water). Within each of the two levels of corn moisture tested, either no enzyme (control) or 0.0075 lb. of one of three commerical enzyme preparations was fed per steer daily. The treatments and daily gains were: control (no enzyme), 2.19; Agrozyme, 1.78 lb. (significant at the 5% level); Diazyme, 2.05 lb.; HT 550-F, 2.01 lb. Levels of corn silage and supplement were held constant among the 8 lots, but the consumption of shelled corn was depressed from 7 to 16% by enzyme feeding. The first four lots fed regular moisture corn gained 2.09 lb. per day and the last four lots fed ensiled high moisture shelled corn gained 1.95 lb. After 140 days the design was altered to check any interaction between oral diethylstilbestrol (DES) and enzymes. The treatments and daily gain were: control (no enzyme, no DES), 1.73 lb.; 10 mg. DES per day, 2.02 lb.; 0.0075 lb. HT 550-F per day, 1.80 lb.; DES plus HT 550-F, 2.05 lb.

178. ORAL IRON REQUIREMENT OF THE EARLY-WEANED PIG. R. A. Pickett, M. P. Plumlee, W. H. Smith and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Four experiments were conducted to determine the dietary iron requirement of the early-weaned pig. Duroc pigs weaned at 10–14 days of age were allotted to treatment by weight, age and litter. Hemoglobin, hematocrit and RBC determinations were made weekly on each pig during the 42-day experiments. In experiment I the pigs were fed two different semi-purified basal diets. Basal I (15 ppm. iron) contained dried skim milk as a source of protein and basal II (40 ppm. iron) contained casein as a source of protein. Iron as ferrous sulfate ($Fe_2SO_4 \cdot 2H_2O$) was added at 0 or 100 ppm. The pigs grew at a slower rate on the DSM basal than on the casein basal but development of anemia was similar in both groups. Growth response to added iron was greater on the DSM ration but both groups had a similar hematological picture. The DSM basal was used in experiments II, III and IV with ferrous sulfate added to give rations with total iron levels of 15, 30, 40, 50, 60, 65, 70, 80, 90, 100, 115 and 120 ppm. Levels of 15, 30, 40 or 50 ppm. iron resulted in reduced growth rate while levels of 60 or more produced normal growth. Erythrocyte concentration was reduced at levels up to 60 ppm. iron while hemoglobin and hematocrit were reduced significantly at iron levels up to 80 ppm.

179. GROWTH AND REPRODUCTIVE PERFORMANCE OF BEEF HEIFERS AS AFFECTED BY WIDELY DIFFERING LEVELS OF WINTER FEEDING. Don Pinney, L. S. Pope and D. F. Stephens, *Oklahoma Agricultural Experiment Station in cooperation with Animal Husbandry Research Division, USDA, ARS.*

In two trials involving 60 grade Hereford heifers each, the accumulative effects of four different levels of feeding from November to mid-April were studied. Supplemental feed (cottonseed meal and milo) on native winter pasture was varied in an attempt to obtain the following weight gains as weaner calves: Low level, no gain; medium, 0.5 lb. per day; high, 1.0 lb. per day, and very high, maximum gain (self-fed a 65% concentrate ration). Gains in second and subsequent winters were: Low, 20% loss of body weight; medium, 10% loss; high, no loss, and very high level, maximum gain. All heifers grazed native grass year-long, calved first as two-year-olds in February and March, and weaned calves in mid-October. Data to 3 years of age for one group and 2 years of age for another have now been obtained. Level of nutrition significantly affected all body measurements taken, but had its least effect on height of withers. Summer gains of low and medium level heifers tended to compensate for poor winter feeding. Percentage calf crop was reduced for low and very high level treatments. Calving dates were retarded and birth weights significantly reduced by the low level. Weaning weights of the calves were significantly lighter for the low level, with little difference between the other levels. Results indicate that the low level adversely affected the heifers. There was no advantage to a feeding regime more liberal than the medium level.

180. PHYTIC ACID AND UNIDENTIFIED GROWTH FACTOR RESPONSE IN SWINE. M. P. Plumlee, D. R. Whitaker, W. H. Smith, J. H. Conrad, H. E. Parker and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Seventy-two, 3-week-old pigs, six per treatment, were self-fed semi-purified rations which contained 0.70% Ca, 0.47% P and 20.2% protein. Either purified soybean protein or casein was fed. For experiment 1, the treatments, Zn content of diets in ppm., daily gain and feed per lb. gain for 49 days were: (1) soy basal, 50., 0.48, 2.5; (2) soy + isopropanol-insoluble residue (IIR) of DDS, 42, 0.37, 3.4; (3) soy + 5% DDS, 41, 0.62, 2.2; (4) casein basal, 22, 0.81, 1.8; (5) casein + 0.61% phytic acid (PA), 22, 0.35, 2.7; and (6) casein + 0.61% PA + 5% DDS, 32, 0.33, 3.1. Daily gain of lot 4 was higher ($P<.01$) than either lots 1, 2, 5 or 6. Three, 6, 2, 0, 6 and 6 cases of parakeratosis developed in lots 1 through 6, respectively. Treatments, gains and feed per lb. gain for the 28-day repletion phase were: (1) soy basal, 0.73, 3.2; (2) soy basal except 5% corn oil, 0.90, 2.7; (3) soy + 100 ppm. Zn, 1.58, 3.5, (4) casein + 0.61% PA, 1.53, 2.3; (5) casein, 1.58, 1.9; and (6) casein + 0.61% PA + 5% DDS + 100 ppm. Zn. 1.56, 2.0. Gains of lots 3, 4, 5 and 6 were higher than lot 1 ($P<.01$) and lot 2 ($P<.05$). In experiment 2, treatments, Zn content of rations in ppm., daily gains and feed per lb. gain for the 56-day period were: (1) soy basal, 116, 0.66, 2.4; (2) soy + IIR of DDS, 116, 0.66, 2.4, (3) soy + 5% DDS, 116, 0.86, 2.3, (4) casein basal, 16, 1.0, 2.2; (5) casein + 0.61% PA, 16, 0.32, 3.2; and (6) casein + 0.61% PA + 100 ppm. Zn, 116, 0.87, 2.1. Gains of lots 1 and 2 were lower than lots 3 ($P<.05$) and lot 4 ($P<.01$). Gain and feed efficiency were lower in lot 5 ($P<.01$) than any other lot. Five pigs in lot 5 developed parakeratosis. Either 100 ppm. Zn or 500 ppm. EDTA were equally effective in improving gain and skin condition.

181.

182. CONTINUOUS FEEDING OF CHLORTETRACYCLINE TO LACTATING DAIRY COWS. C. E. Polan, G. A. McLaren, I. D. Porterfield, H. O. Henderson and R. S. Dunbar, Jr., *West Virginia University, Morgantown.*

The effect of continuous feeding of chlortetracycline on the health, breeding, digestibility of nutrients and butterfat production of dairy cows was determined over two lacation periods. Starter activity in inoculated milk samples from the cows was also measured. Fourteen Ayrshire and two Guernsey cows were paired according to real producing ability of butterfat and randomly placed in either a treatment or a control group. Both groups were fed and managed in the same manner, but the treatment group received 0.1 mg. chlortetracycline per pound of body weight per day. Six of the cows in the treatment group and four in the control group were continued into the second lactation period. Health data for 18 months showed that chlortetracycline feeding exerted no preventive control on scours, mastitis, ringworm or foot rot. There were no significant differences between the groups with respect to conception rate, butterfat production, and starter activity in inoculated milk samples. Crude fiber digestibility was depressed ($P<.08$) in the chlortetracycline fed cows, but the digestibility of other nutrients was not significantly changed.

183. PLACENTAL AND MAMMARY TRANSFER OF IRON-DEXTRAN GIVEN INTRAMUSCULARLY DURING GESTATION OR LACTATION. W. G. Pond, R. S. Lowrey, J. H. Maner and J. K. Loosli, *Cornell University, Ithaca, New York.*

Levels of approximately 0, 2, 2.5, 5 and 10 mg. of Fe per lb. body weight were injected intramuscularly into 11 sows 6–9 days after farrowing. Analysis of milk samples obtained before and at various intervals following the injection revealed that little or no mammary transfer of the Fe occurred. Four sows were injected at 100 days gestation with 0, 2, or 10 mg. of Fe per lb. body weight. Pigs from all four sows (total of 39 pigs) had Hb values averaging less than 5 gm. % at 10 days of age. At this time the pigs were assigned according to Hb level to the following treatments: (1) 200 mg. Fe from ferric oxide, (2) 400 mg. Fe from ferric oxide, (3) 200 mg. Fe from ferrous sulfate, (4) 400 mg. Fe from ferrous sulfate, (5) 150 mg. Fe from iron-dextran given intra-muscularly and (6) negative control. Ferric oxide and ferrous sulfate were given in water solution by stomach tube. Twenty-three days after treatment average Hb (gm. %) and body weight (lb.) of pigs in groups 1–6 out of dams not injected with Fe during gestation were, respectively (no. of pigs per group in parenthesis): 5.8, 17.4 (3); 4.9, 17.4 (3); 5.4, 15.5 (3); 8.0, 15.3 (3); 10.2, 18.3 (3); 5.3, 13.5 (2). Corresponding values for pigs out of dams injected with 2 or 10 mg. of Fe per lb. body wt. were 4.4, 12.9 (4); 4.2, 14.3 (4); 4.9, 12.1 (4); 5.9, 15.2 (4); 9.6, 16.7 (4); and 3.9, 13.3 (2). These data indicate that insufficient Fe is available to the pig from placental transfer to meet requirements for normal growth and Hb. A single oral dose of 400 mg. ferrous iron appeared to be slightly superior to the ferric form in maintaining Hb levels.

184. SUPPLEMENTAL FEEDING OF WHOLE COTTONSEED AND COTTONSEED MEAL TO BEEF STEERS. Dallas Powell, Jim Neill, J. H. Baumgardner and Ralph M. Durham.

One hundred forty yearling steers were used in two trials comparing whole cottonseed with cottonseed meal as the sole protein supplement. Additives were not used. Sixty Angus cattle in trial 1 were allotted to three treatment groups of 20 each and fed for 125 days. Lot 1 was fed 1 pound of meal, lot 2 was fed 2 pounds of whole cottonseed and lot 3 was fed 3.5 pounds of whole cottonseed. Lots 1 and 2 received 17 lb. of milo and lot 2, 13 lb. of milo, with silage *ad libitum* for all lots. Trial 2 involved 80 steers allotted to four treatment groups. Two groups were fed 2 lb. per head

of cottonseed for 50 days and two groups 1 pound of meal, together with 15 and 16 lb. milo, respectively, and silage *ad libitum*. One group on each supplement was maintained throughout the period on that grain level and the other group was finished on a high grain level. The results indicated small and non significant differences in gain between seed and meal groups, although the meal fed lots made the highest gains in both trials. There were no differences in carcass yields, but the meal-fed cattle had a slightly higher percentage of choice carcasses in trial one. However, marbling scores did not differ between seed and meal lots in either trial. The high grain lots in trial 2 gained significantly faster and more economically than the 16-pound lots. High grain lots yielded heavier carcasses and had significantly higher marbling score.

185. EFFECTS OF CERTAIN MINERAL COMPOUNDS ON THE INCIDENCE OF URINARY CALCULI IN LAMBS IN WESTERN OKLAHOMA. David R. Pratt, Milton W. England and Janet L. C. Rapp, *Oklahoma Panhandle A. & M. College, Goodwell, and Feed Service Corporation, Crete, Nebraska.*

The effect of NaCl, KCl, Ca_2SO_4, NaH_2PO_4 and dolomitic limestone on feeder lambs was tested in Western Oklahoma by making each of these available on an *ad libitum* basis in addition to the experimental rations. Five lots, each of 20 lambs averaging 61 lb. at the start were fed 78 days. One lot (3) received Morea (a liquid protein supplement containing urea, ethanol, and various minerals) on a free-choice basis as the only protein supplement to the basal ration of cracked milo, sorghum silage, and alfalfa hay. One lot (1) received Morea free-choice plus 15% CSM added to the milo, and one lot (2) received no silage. The only lot in which there were no known cases of urinary calculi was Lot 3. One lamb in each of Lots 1, 2, and 5 and two lambs in Lot 4 (cottonseed meal) developed urinary calculi. At the conclusion of the test, the average blood magnesium level was higher in Lot 4 than in the other lots. There appeared to be some factor in the liquid supplement (presumable phosphoric acid and/or ethanol) which tended to reduce the incidence of urinary calculi.

186. PERFORMANCE CHANGES IN LAMBS FED CONCENTRATE AND ROUGHAGE AT VARYING TIMES. R. L. Preston and W. H. Pfander, *University of Missouri, Columbia.*

A study was made to determine if the time of feeding the concentrate and roughage portions of a lamb's ration would have an effect upon feedlot performance. Thirty-two lambs (av. 76 lb.) were allotted to four lots by outcome groups and fed for 62 days according to the following randomly assigned treatments: Lot I—roughage (a.m.), concentrate (noon), roughage (p.m.); Lot II—roughage (a.m.), concentrate (p.m.); Lot 3—concentrate (a.m.), roughage (noon), concentrate (p.m.); Lot IV—complete ration (a.m., p.m.). All feeds were ground and pelleted. The roughage was mixed grass hay; the concentrate was a mixture of 67% corn, 23% soybean meal, 8% molasses, minerals and vitamins. The complete ration was calculated to contain 13% protein. Average daily gain (lb.), feed intake (lb.), and lb. feed/lb. gain, respectively, were: Lot I—0.56, 3.8, 6.7; Lot II—0.55, 2.9, 5.2; Lot III—0.66, 3.3, 5.0; Lot IV—0.60, 3.7, 6.1. Dressing percent and carcass grade were higher in Lots III and IV than in Lots I and II. Rumen papillae were much longer and larger in lambs from Lot III, followed by II and IV. Lot I lambs had the least papillae development. Depth of color of the papillae followed a similar order. Slight rumen parakeratosis was noted in four of the lambs from lot III. No other parakeratosis was noted.

187. UTILIZATION OF VARIOUS PROTEINS BY THE BABY PIG AS MEASURED BY PERFORMANCE AND BLOOD AMINO ACID PATTERNS. F. Puchal, J. D. Jones, V. W. Hayes and V. C. Speer, *Iowa State University, Ames.*

Plasma free amino acids have been determined in the young pigs fed five dif-

ferent sources of protein: dried skim milk, soybean oil meal, cottonseed oil meal, fish meal and meat scraps. The plasma amino acid patterns point out, by comparison with the concentrations found in the animals fed milk proteins, some of the amino acids which may be responsible for the inadequacy of these dietary proteins to maintain an optimum rate of body gain when fed in a practical ration without any additional supplementation. From the data obtained, methionine, leucine and phenylalanine appear to be most limiting in soybean oil meal; lysine, leucine, isoleucine and possibly the sulfur amino acids in cottonseed oil meal; isoleucine and leucine in meat scraps; and phenylalanine and isoleucine in fish meal. A much higher plasma value for most amino acids was evident in the animals fed dried skim milk, as compared to the other protein sources, especially for the two sulfur containing amino acids, methionine and cystine. Blood urea levels were inversely related to performance, varying from 13.4 mg. urea per 100 ml. plasma for the pigs fed dried skim milk up to 33.0 mg. for pigs fed meat scraps, these proteins resulting in the best and the poorest performance, respectively. The two diets giving the lowest blood concentrations for more amino acids were cottonseed oil meal and meat scraps, which went along with the poorer growth and feed efficiency given by these two proteins as compared to the other three diets. A very high value for blood glycine, 171 μM and 164 μM per 100 ml. of plasma for pigs fed meat scraps and fish meal as compared to 62 μM for those fed dried skim milk may have an indirect relationship to relative performance.

188. DIETARY FACTORS INFLUENCING THE PRODUCTION OF RUMINAL VOLATILE FATTY ACIDS. Ned S. Raun and Wise Burroughs, *Iowa State University, Ames.*

Samples of rumen fluid were taken four hours after feeding fistulated sheep high concentrate-low roughage type rations supplemented with sodium bicarbonate, potassium bicarbonate, calcium carbonate, magnesium carbonate, lactic acid and vitamin B_{12}. A simple gas chromatographic technique was developed whereby dry distilled ethyl esters of the short-chain fatty acids were volatilized directly into a gas chromatograph used to determine molar ratios of acetate, propionate, iso-butyrate, n-butyrate, iso-valerate and n-valerate. Measurements of rumen fluid volatile fatty acid levels, pH, buffering capacity and lactic acid levels were also determined. Increasing the concentrate level of the sheep's diet progressively increased ruminal propionate with little effect on butyrate levels. The carbonate and other supplements tested had varying effects in the volatile fatty acids produced.

189. RESPONSE OF LAMBS TO ENERGY AND PROTEIN LEVELS, HORMONE IMPLANTS AND ENZYMES. John C. Rea and C. V. Ross, *University of Missouri, Columbia.*

The effects were studied in three factorially designed experiments. Initially 208 lambs were self-fed complete pelleted rations comparing response of stilbestrol versus hexestrol implants, high and low energy, and 11% and 14% protein in rations. Lambs on high energy rations gained significantly faster and more effectively than lambs on low ($P<.01$). Lambs on 14% crude protein gained faster and more efficiently than those on 11%. High energy—high protein resulted in faster gains and higher carcass yields than any other combination of energy and protein. Implanting with hexestrol resulted in some improvement in efficiency factors when compared with stilbestrol, but this was statistically insignificant. Fifty-four lambs were individually fed (Trial 2) to study effects of hexestrol implants on lambs fed rations containing 11, 13, and 15% protein. Implanted lambs made significantly faster ($P<.01$) and more efficient gains than controls. Gains and feed efficiency tended to improve as dietary protein increased. Effect of stilbestrol and enzymes on lambs fed

high and low energy rations containing 11, 12, 13, and 14% protein was studied with 192 lambs in Trial 3. Results were similar to Experiment 1. Lambs on high energy rations gained faster and more efficiently with higher carcass yields than those on low energy. High protein—high energy supported faster gains than other combinations. Stilbestrol-implanted lambs gained faster and equaled controls in grades. There was no apparent response to enzymes added to rations.

190. NUTRIENT ADDITIONS AND PHYSICAL FACTORS THAT INFLUENCE LAMB PERFORMANCE ON HIGH CONCENTRATE PELLETED RATIONS. Robert W. Rhodes and Walter Woods, *Iowa State University, Ames.*

A series of growth trials were conducted to study the effect of fortification and pellet size on performance of lambs individually fed high concentrate (67%) pelleted rations. The rations compared in trial 1 were: (1) basal mixed, containing alfalfa hay, (2) pelleted basal (5/16"), (3) pelleted basal (1"), (4) ration 2 + minerals and vitamins, (5) pelleted ration containing oat hulls, (6) ration 5 + minerals and vitamins. Daily gains for ration 1 through 6 were: 0.46, 0.45, 0.50, 0.50, 0.36, 0.41 lb. respectively. In trial 2 the comparisons were: (1) basal mixed, containing alfalfa hay, (2) pelleted basal (5/16"), (3) pelleted basal (1"), (4) ration 2 + minerals and vitamins, (5) ration 3 + minerals and vitamins, (6) ration 2 + minerals, (7) ration 2 + vitamins and (8) ration 2 + $NaHCO_3$. Daily gains for rations 1 through 8 were: 0.42, 0.58, 0.44, 0.54, 0.51, 0.49, 0.52 and 0.61 lb. respectively. In trial 3 the comparisons were: (1) basal mixed, containing alfalfa hay, (2) ration 1 + minerals and vitamins, (3) pelleted basal, (4) ration 3 + vitamins and minerals, (5) ration 3 + calcium and phosphorus, (6) ration 3 + trace minerals, (7) ration 3 + B vitamins, (8) ration 3 + $NaHCO_3$. Daily gains for rations 1 through 8 were: 0.44, 0.53, 0.52, 0.54, 0.54, 0.60, 0.53, and 0.52 lb. respectively. Changes in rumen coloration were found due to pelleting. Butyric acid utilization by rumen epithelium from lambs on mixed or pelleted rations tended to be higher than from lambs on long hay rations. Rumen pH was lower for lambs on pelleted rations. Differences in digestibility were due to pelleting but not to fortification.

191. EFFECT OF COBALT BULLETS IN BEEF CATTLE RATIONS. D. Richardson, W. S. Tsien, B. A. Koch, J. K. Ward, E. F. Smith and F. W. Boren, *Kansas State University, Manhattan.*

Six lots each of 10 heifers averaging 466 lb. were fed a fattening ration of sorghum silage, soybean oil meal, ground corn, and a mineral mixture of bonemeal and salt. Three lots received 1 lb. of alfalfa hay per head daily. Five animals in each of the six lots received a 20-gm. bullet containing 90% cobalt oxide. The feeding period was 215 days. The average daily gain (1.70 lb.) was significantly greater ($P<.01$) for animals receiving cobalt than those not receiving cobalt (1.51 lb.). There were no significant differences in carcass grade. Without alfalfa in the ration, difference in average daily gain (1.49–1.74 lb.) also was significant ($P<.01$), but there was no significant difference with alfalfa (1.54 vs. 1.66 lb.). Analyses showed that the average ration without alfalfa supplied 1.214 mg. cobalt per head daily; with alfalfa, 1.416 mg. There were no significant differences in total amount or percentage of rumen fluid, acetic, propionic or butyric acid. Four lots of 10 steers each, averaging 560 lb., were fed a wintering ration of sorghum silage, soybean oil meal, sorghum grain, 1 lb. of alfalfa (either as hay or dehydrated pellets) and a mineral mixture of bonemeal and salt. Five animals in each lot received a cobalt bullet. There were no significant differences in average daily gain or total amount or percentage of rumen volatile fatty acids.

192. EFFECT OF VARIOUS DRYING TEMPERATURES ON THE VALUE OF CORN IN BEEF CATTLE FATTENING RATIONS. D. Richardson, J. K. Ward, W. S. Tsien, F. W. Boren, E. F. Smith and B. A. Koch, *Kansas State University, Manhattan.*

Irrigated corn was harvested containing about 25% moisture. It was divided into three batches and dried to approximately 13% moisture by forced air at the following temperatures: (1) control, no heat; (2) air at 180° F.; (3) air at 230° F. Corn dried at 230° F. faded, separated from seed coat when rolled and was not readily acceptable to the cattle; however, palatability was not a serious problem after the animals became adjusted to it. Field mice did not eat this stored corn when corn dried without heat was available. Corn dried at 180° F. exhibited the above characteristics to a much lesser degree. Three lots each of 10 Hereford heifers averaging 466 lb. were fed for 215 days on grain dried under the above conditions. Feeding results showed no significant differences in rate of gain, feed efficiency, dressing percentage, marbling or carcass grade. There were no significant differences in total millimols per 100 ml. of acetic, propionic or butyric acids in rumen fluid or in the proportions of acetic and butyric acids. The proportion of propionic acid increased at higher drying temperatures with levels of 23.2, 26.7 and 28.1%, respectively, for the control, 180° F., and 230° F. drying temperatures. Differences in the proportion of propionic acid approached significance at the 5% level.

193. MOISTURE CONTENT OF SORGHUM GRAIN AND URINARY CALCULI IN STEERS. J. K. Riggs and H. R. Crookshank, *Texas Agricultural Experiment Station, College Station, and U. S. Dept. of Agriculture.*

Weanling steers fed a growing ration for 112 days followed by a fattening ration for 140 days were found to have much less calculi in the bladder when sorghum grain of high moisture content was used in the ration. Using sudan grass in the form of hay or haylage did not appreciably affect the quantity of stones. The incidence of calculi was high in all lots.

194. EXCESS DIETARY MANGANESE AND FEED LOT PERFORMANCE OF BEEF CATTLE. N. W. Robinson, Sam L. Hansard, D. M. Johns and G. L. Robertson, *Louisiana Agricultural Experiment Station, Baton Rouge.*

Conventional digestibility investigations and clinical changes in tissues and peripheral blood were employed to study effects of excess dietary manganese upon feed lot performance of 48 yearling Hereford calves. Animals were maintained in four lots for 160 days on a corn, CSM, molasses and Bermuda grass hay ration, supplemented with 0, 250, 500 and 1000 ppm. manganese ($MnSO_4$) respectively. Daily gains averaged 1.63, 1.51, 1.57 and 1.58 lb./day, and feed efficiencies for the respective lots were 9.8, 10.6, 10.2 and 10.2 lb. Results of periodic blood analyses showed no consistent effect of dietary manganese level upon cell pack volume, hemoglobin, plasma iron, calcium or phosphorus content. Excess manganese had no significant effect upon calcium or phosphorus retention, but decreased iron absorption and reduced fiber digestibility. Ability of rumen microorganisms to digest cellulose *in vitro* was markedly reduced in animals on high dietary manganese levels. Tissue analyses at sacrifice showed increased manganese storage and iron depletion. Greatest concentration changes were evidenced in liver, spleen and hypophysis. Data indicate the effects of excess manganese to be greater on function than structure in tissues and organs studied.

195. EFFECT OF HEATING STARCH ON ITS DIGESTION BY RUMEN MICROORGANISMS. R. L. Salsbury, J. A. Hoefer and R. W. Luecke, *Michigan State University, East Lansing.*

Corn starch was subjected to various heat treatments, then used as the substrate for microorganisms in rumen fluid from which the protozoa and plant material had

been removed by centrifugation. Starch was determined as readily hydrolyzable dry matter. Percentage disappearance at 3, 6, 9 and 12 hr. was 0, 10, 23 and 43 for untreated starch, 0, 12, 36 and 47 for dry heated (12 hr.) starch, 3, 16, 34 and 47 for autoclaved (10 min.) starch—8, 34, 50 and 59 for starch autoclaved with 0.5 part water, 25, 58, 61 and 58 for starch autoclaved with 18 parts water, and 31, 42, 45 and 46 for bread. A commercial heated corn was digested at a faster rate than ground corn, and autoclaving the heated corn with water only slightly increased its rate of digestion. Microscopic examination of the substrates indicated that, in contrast to the more slowly digested starches, the more rapidly digested starches had been subjected to appreciable hydration. Results are in keeping with the concept that commercial heating of corn brings about hydration of its starch which is then more readily attacked by rumen microorganisms.

196. DIGESTIBLE ENERGY AND NITROGEN, AND RATE OF FOOD PASSAGE IN PIGS FED MEAL AND PELLETS. R. W. Seerley, J. A. Hoefer and E. R. Miller, *Michigan State University, East Lansing.*

Studies with paired market weight pigs were conducted simultaneously to determine the effect of pelleting upon digestibility and rate of food passage. The two rations used were (1) fortified corn-soybean meal and (2) 40% oats by weight replacing corn. Steam was used to condition the meal before pelleting. Feed and fecal determinations were made in a Parr plain-jacket oxygen bomb calorimeter. When equally fed, meal and pellet apparent digestible energy values were (1) high corn, 82.54%, and 84.61% (2) 40% oats, 75.45% and 76.88%, respectively. Digestibility of the high corn ration was significantly improved by pelleting. When allowed to eat *ad libitum*, the results for meal and pellets were (1) high corn, 81.88% and 84.45%, and (2) 40% oats, 78.80% and 75.82%, respectively. The difference between meal and pelleted 40% oat rations was significant. Apparent digestible nitrogen values were not significantly different. Rate of food passage was estimated by feeding and recovering dyed ground corn cob particles. The 5%, 95% particle excretion time, and mean particle retention time (R) were used to analyze the data. With equal feeding, the meal and pellet average (R) values (hr. after feeding) were (1) high corn, 35.8 and 29.3, and (2) 40% oats, 37.2 and 33.4, respectively. With *ad libitum* eating, the meal and pellet average (R) values were (1) high corn, 47.8 and 25.3, and (2) 40% oats, 39.4 and 27.2, respectively. Pooled ration data showed that pelleted mean particle retention time was significantly less than the meal. This indicated faster passage with pellets. The 5% and 95% excretion times were consistently less with the pelleted rations.

197. GROWTH AND FEED EFFICIENCY STUDIES WITH PIGS FED MEAL AND PELLETS. R. W. Seerley, J. A. Hoefer and E. R. Miller, *Michigan State University, East Lansing.*

Six replicate pairs of weanling pigs were equally fed meal and pelleted rations to approximately 180 lb. bodyweight, then allowed to eat *ad libitum* to heavier weights. The three rations used were (1) fortified corn-soybean meal, (2) 20% oats by weight replacing corn, and (3) 40% oats by weight replacing corn. Meal rations were made into 3/16 inch pellets by a California pelleting mill. Steam was used to condition the meal before pelleting. Pigs were individually fed twice daily. During the equal feeding phase, the quantity of feed provided at each feeding was based on the consumption by the pig eating the lesser amount. Comparing meal and pellet forms of the (1) high corn, (2) 20% oat, and (3) 40% oat rations, when equally fed, average daily gains (and feed per lb. of gain) were (1) 1.47 (3.36), 1.58 (3.14); (2) 1.39 (3.39), 1.45 (3.26); (3) 1.45 (3.43), 1.53 (3.27), respectively. Pelleting the high corn ration significantly improved daily gains and feed efficiency. With pooled ration data, values were 1.44 (3.39) and 1.51 (3.23), meal and pellets, respectively. Pelleting significantly improved gains and feed efficiency. When these same rations were eaten

ad libitum, the results for meal and pellets were (1) 1.82 (3.93), 2.03 (3.67); (2) 1.50 (4.44), 1.92 (4.36); (3) 1.88 (4.56), 2.21 (3.85), respectively. Average daily gains were significantly faster with the pelleted 20% and 40% oat rations. With pooled ration data, the meal and pellet results were 1.71 (4.26) and 2.03 (3.97), respectively. Growth rate and feed efficiency were significantly different between the meal and pellets.

198. PROTEIN-ENERGY RELATIONSHIPS IN THE RATIONS OF EARLY WEANED PIGS. R. F. Sewell and M. C. Thomas, *University of Georgia, Athens.*

Two experiments involving 114 pigs weaned at 3 weeks of age were conducted to study protein-energy relationships. A fortified corn-soybean oil meal ration was fed in Trial 1, and a ration composed of purified ingredients in Trial II. A 2 x 3 factorial experiment with two levels of energy at three levels of protein was used in each trial. Protein levels were 10, 15 and 20%. Highly significant treatment effects were obtained in each trial. The treatment differences were largely due to the protein linear component of variation. Growth rate increased markedly when the protein level was increased from 10% to 15%. Further increases in the protein content of the ration to 20% resulted in faster gains in Trial I but not in Trial II. Feed required to produce a unit of gain decreased linearly as the protein level of the rations was progressively increased. Increasing the energy density of the ration by the addition of corn oil increased rate of gain with a corresponding improvement in efficiency of feed utilization at both the 10% and 15% protein levels in Trial II. Under the conditions imposed in these experiments, it appears that a calorie-protein ratio, expressed as productive energy, of between 50:1 to 55:1 produced maximum performance.

199. THE VALUE OF A STEROIDAL SAPOGENIN IN THE RATIONS OF FATTENING LAMBS AND BEEF CATTLE. W. C. Sherman, W. H. Hale, W. M. Reynolds and H. G. Luther, *Chas. Pfizer & Co., Inc., Terre Haute, Indiana.*

The substance tested was smilagenin, a steroidal sapogenin of plant origin. It was selected because it is not known to have estrogenic activity, but information on possible growth-promoting action is lacking as well as on possible side effects and influence upon carcass quality. In lamb trials this steroid was fed in a high-grain pelleted complete ration. Smilagenin at 2 to 24 gm. per ton of feed improved rate of gain and feed efficiency, most consistent results being obtained with 8 gm. per ton for which average increase in rate of gain was 24% above controls and average feed efficiency increase was 19%. In one cattle experiment, 20 mg. smilagenin brought about an increase of 0.27 lb. in average daily gain, and 10 mg. stilbestrol brought about an increase of 0.15 lb. A level of 100 mg. smilagenin was less effective than 20 mg. In a second cattle experiment, smilagenin at 20 mg. per head per day increased gains by 0.17 lb. per day, and 10 mg. stilbestrol daily increased gains by 0.31 lb. In both cattle experiments, the improvement in feed efficiency resulting from 20 mg. of smilagenin was greater than from 10 mg. stilbestrol. There was an indication that feeding smilagenin improved carcass quality of lambs, but not of cattle.

200. EFFECT OF DIETARY PROTEIN AND AGE ON GLYCOGEN AND LACTIC ACID OF SEVERAL TISSUES OF CATTLE. R. L. Shirley, Eliezer Bedrak, R. H. Alsmeyer, F. M. Peacock, W. G. Kirk, A. C. Warnick, J. W. Carpenter, A. Z. Palmer and G. K. Davis, *University of Florida, Gainesville.*

Glycogen was determined in the gracilis muscle, heart and liver of (1) 20 heifers that were divided equally at 26 months of age and fed 1.34, 1.06, 0.71 and 0.62 lb. crude protein per animal per day for 6 months, (2) 16 cows, 3 to 4 years old and their 7-month-old calves, and (3) 35 steers that were equally divided into age groups of approximately 7, 10, 12, 13 and 15 months. Lactic acid was determined in the (a) muscle, heart and liver of the 20 heifers and (b) in the muscle and heart of the cows

and calves. As the dietary protein was decreased the glycogen in the liver increased (approached $P<0.05$), but there was no change in the muscle and heart. The lactic acid decreased (approached $P<0.05$) in the heart but not in the muscle and liver as the protein was decreased. The cows had more ($P<0.01$) glycogen in their muscle and liver than their calves, but the lactic acid was unaffected in the heart and muscle. The heart decreased ($P<0.05$), while muscle and liver increased ($P<0.05$) in glycogen content in the steers with increase in age.

201. INFLUENCE OF DELAYED CASTRATION AND OF DIETHYLSTILBESTROL IMPLANTS ON DAILY GAIN AND CARCASS GRADE OF NATIVE LAMBS. R. H. Simms, F. N. Andrews, T. W. Perry and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

The effect of diethylstilbestrol (DES) implantation on the growth rate and carcass quality were studied in a total of 290 suckling lambs during a two-year period. The ewes were of mixed Rambouillet, Hampshire and Suffolk breeding. Comparisons were made between intact male, castrate male, and ewe lambs. The DES treated ewe lambs received 3, 6 or 12 mg. implants in 1959 only. In 1959 and 1960 the ram lambs were implanted with either 12 or 24 mg. of DES. Ewe, castrate male, and intact males served as controls. There was a small increase in growth rate with DES administration to ewe lambs (0.51, 0.52 and 0.55 lb. per day as compared to 0.51 for the control lot). The carcass quality was increased with 3 mg. of DES (7.42 "C—" versus 7.21 "C—" for control lot) but decreased with additional hormonal units (6.00 "G+" for 6-gm. lot and 6.21 "G+" for 12-mg. group). Implanted DES did not increase the growth rate of intact or castrate male lambs in the 1959 study. The treated groups gained from 0.53 to 0.64 lb. per day as compared to the intact male lambs which gained 0.66 lb. per day. However, the carcass grades of the hormonal-treated males were higher (7.10 "C—") than the controls (6.07 "G+" and 6.50 "G+"). In the 1960 phase, intact males gained 0.50 lb. per day; intact males implanted with 12 mg. DES at 10–14 days of age, 0.56 lb.; intact males implanted at 40 lb. liveweight, 0.52 lb.; and males castrated at 10–14 days of age, 0.48 lb. Carcass grades were highest for intact males implanted at 40 lb., followed by males castrated at 10–14 days, intact males implanted at 10–14 days, and unimplanted intact males.

202. EFFECT OF THE RATION FED TO PREGNANT GOATS IN THE DEVELOPMENT OF MUSCULAR DYSTROPHY IN THEIR KIDS. C. N. Skipitaris, *University of Thessaloniki, Thessaloniki, Greece.*

A condition of paralysis in young suckling kids occurred sporadically from 1954–1958 at Stockbreeding Station of Drama-Greece where the ration of the goats during gestation consisted of alfalfa hay, horse beans, corn, oats and barley. Two feeding experiments have been conducted to find out if this paralysis has any relation to the nutritional muscular dystrophy reported in several countries with lambs and calves and which is associated with the feeding of pregnant cows and ewes legumes grown only in certain locations and particularly following the use of common fertilizers on irrigated land. In the first experiment during the season 1958–59 the alfalfa hay and horse beans were derived from unfertilized fields. Three lots of 14 goats each were fed as follows: Lot 1—alfalfa hay and horse beans; Lot 2—alfalfa hay, corn, oats, wheat bran and wheat shorts; Lot 3—alfalfa hay, horse beans, corn, oats, wheat bran and wheat shorts. Not a single paralytic kid was produced in any lot. In the second experiment during the season 1959–60 all the alfalfa hay and part of the horse beans were derived from an irrigated field fertilized with sulphate of ammonia and superphosphate. Forty-three goats were allotted in three lots of 18, 18 and 7 goats respectively, and were fed during gestation and lactation as follows: Lot 1—alfalfa hay, horse beans, oats and barley; Lot 2—alfalfa hay, corn, oats, wheat bran and wheat shorts; and Lot 3—alfalfa hay, cull beans, oats, and barley. The observed

clinical signs of muscular dystrophy in the kids were: Lot 1—10 of 20; Lot 2—1 of 26; Lot 3—1 of 10. Post mortem histopathological examination at the Laboratory of Pathological Anatomy clearly revealed the characteristic muscular lesions of the white muscle disease.

203. ARSANILIC ACID PROPHYLAXIS FOR HEMORRHAGIC DYSENTERY IN SWINE. I. D. Smith, E. M. Kiggins, H. S. Perdue, J. C. Holper and D. V. Frost, *Abbott Laboratories, North Chicago, Illinois.*

Two experiments involving 196 pigs were conducted to evaluate graded levels of arsanilic acid (AA) for the control of hemorrhagic dysentery. In one experiment 96 pigs weighing approximately 145 lb. and suffering in varying degrees from hemorrhagic dysentery were allotted to treatment. The treatments (which lasted 4 weeks), percent increase in average daily gains over the controls, and feed per lb. of gain were as follows: Control—0%, 3.94; 0.016% sodium arsanilate in the drinking water—15%, 3.30; the following levels of AA in a complete ration, 0.01% AA—25.7%, 3.36; 0.02% AA—27.1%, 3.34; 0.025% AA—28.6%, 3.01; and 0.1% AA in a protein supplement fed free-choice with corn—2.8%, 3.59. For an experiment on pasture 100 weanling pigs were placed on their respective test rations 3 days prior to exposure to infection. Half of the pigs from each treatment were orally challenged with a milk suspension of homogenized gastrointestinal tracts from pigs suffering with hemorrhagic dysentery. The remaining half were exposed to the infection by housing them with the orally challenged animals. The treatments, average daily gains, feed per lb. of gain and percent mortality 7 weeks post challenge were as follows (40 pigs were used for the controls and 20 pigs for each treatment): Control—1.13, 3.25, 12.5%; 0.01% AA—1.03, 3.10, 10%; 0.02% AA—1.38, 2.78, 0%; 0.025% AA—1.39, 2.70, 5% *Vibrio coli* was detected in all pigs which died except for one pig on the 0.025% AA treatment.

204. IRON REQUIREMENT AND EFFECT OF B-VITAMINS ON THE PERFORM OF GROWING LAMBS. W. H. Smith, M. J. Lawlor, M. P. Plumlee and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Two factorial experiments involving 42 lambs were carried out. A semi-purified diet containing solka-floc, isolated soybean meal, corn starch, cerelose and corn oil was fed. In the first experiment there were four treatments with six lambs on each. The dietary level of iron in the treatments was 70, 140, 210 and 280 ppm., respectively. B-vitamins were added to the diet of half the lambs in each treatment. Blood samples from each animal were assayed weekly for RBC counts, Hb and hematocrit levels. Eighteen lambs averaging 62 lb. liveweight were allotted into three treatments (six lambs per treatment) in the second experiment. Those in treatment 1 did not receive added B-vitamins while riboflavin, niacin and Ca panthothenate were added to the diet in treatment 2, and thiamine, pyridoxine and PABA in treatment 3. Three of the lambs in each treatment received 10 ppm. dietary zinc while the remaining three received 50 ppm. zinc. The lambs were individually fed (*ad libitum*) in both experiments. The results of experiment 1 indicated the Fe requirement of growing lambs to be less than 70 ppm. Dietary Fe levels of 210 and 280 ppm. adversely affected the performance of the lambs by causing scouring and low daily gains. The level of dietary iron did not affect blood values; addition of B-vitamins significantly improved daily gain. In experiment 2, B-vitamins again improved daily gains, but the response was influenced by the presence or absence of added zinc. When either group of B-vitamins was absent, zinc had a stimulating effect, but there was a significant interaction between B- vitamins and zinc resulting in a depressed growth rate.

205. SOME EFFECTS OF VARIED LEVELS OF POTASSIUM NITRATE INGESTATION BY LAMBS. J. H. Sokolowski, U. S. Garrigus, and E. E. Hatfield, *University of Illinois, Urbana.*

Six native lambs averaging 70 lb. received 1000 gm. per head per day of rations containing 0, 4.8, or 6.4% KNO_3 for 129 days. Levels of KNO_3 up to 12.8% of the ration were subsequently fed without causing any visible symptoms of nitrate toxicity. Subsequent drenching the lambs with 64 gm. of KNO_3 resulted in symptoms of extreme nitrate toxicity within 4½ hours after drenching. Methemoglobin reached levels of 70% of total hemoglobin by the 4th hour. In another trial four lambs receiving poor quality alfalfa hay only were given 0.5 gm. KNO_3 per kg. bodyweight by capsule daily. Blood was analyzed for hemoglobin and methemoglobin daily—maximum MHb 1st day was 20%, 2nd day, 10%, 3rd day, 75%. Similar results were noted in another trial involving lambs on bluegrass pasture which received 0.5 gm. KNO_3 per kg. bodyweight daily by capsules. Toxicity symptoms were most severe in the lambs on pasture which received KNO_3 by capsule while the lambs on a complete ration with KNO_3 showed no apparent effects of the nitrate. Lambs are apparently able to counteract nitrate toxicity when on a poor quality ration for about 48 hours. This may be due to detoxification in the rumen by specific microorganisms with the eventual elimination of these organisms by high levels of nitrate. Nitrate N is apparently utilized in a manner similar to other forms of NPN when incorporated in a complete ration for growing fattening lambs.

206.

207. INTERMITTENT FEEDING OF AN ANTIBIOTIC TO PIGS IN DRY LOT. H. S. Teague, *Ohio Agricultural Experiment Station, Wooster.*

The effect on pig performance from different durations of antibiotic supplementation was studied. In three dry lot trials, feed containing 20 gm. of Aureomycin (chlortetracycline) per ton was fed every other week, every other two weeks or continuously from weaning to market weight. During the periods when antibiotic was not included pigs received the basal ration. Replicate lots of seven or nine Duroc and Yorkshire pigs were used in two trials and 15 Poland China X Hampshire crossbred pigs per treatment in the third. Liveweight and feed consumption were determined at weekly intervals. Even though total consumption of antibiotic was the same, a difference in performance resulted from alternate weekly versus biweekly feeding. The response from alternate 2-week feeding was comparable to that obtained from continuous feeding. Even though alternate weekly feeding of the antibiotic-containing ration appeared to be the best method in one trial, in another no improvement in either rate of gain or efficiency of feed conversion resulted. A comparison of the weekly performances of pigs on all treatments showed that neither feed consumption nor rate of gain exhibited an immediate response to the periodic inclusion or exclusion of antibiotic. Combining the first 8-week performance of pigs in all trials (51 pigs per treatment) the controls, those fed antibiotic every other week, every other two weeks or continuously made average daily gains of 1.25, 1.36, 1.39 and 1.41 lb. per day, respectively.

208. ROLE OF SUPPLEMENTAL VITAMINS IN A LEGUME-FREE RATION FOR GILTS IN DRY LOT. H. S. Teague, *Ohio Agricultural Experiment Station, Wooster.*

Three trials were conducted to observe the reproductive performance of gilts when fed a legume-free ration with or without fat soluble and/or water soluble vitamin supplementation. The rations were fed to Duroc gilts for a preliminary period of 30 or 60 days prior to breeding. Reproductive performance of 92 gilts to the 25th

or 57th day of gestation was determined by slaughter and examination of the reproductive organs. Twelve were fed the legume-free ration without vitamin supplementation, and permitted to farrow. Supplemental vitamins A, D and E did not appear to be needed for the support of good performance when there was a 30-day preliminary period prior to breeding and gestation interrupted on the 25th day. However, after a preliminary feeding period of 60 days a lack of A, D and E, or both the fat and water soluble vitamins, was associated with poorer breeding performance in the spring trial, but not in the second trial initiated in the fall. A higher incidence of cystic follicles and anestrus were observed to be the primary causes of breeding failure. The number of corpora lutea, live and dead fetuses were similar for all groups at slaughter. All of the 12 gilts fed the legume-free ration without vitamin supplementation farrowed. The average number of pigs born alive was 9.2 and the average weight of pigs at birth 3.03 lb. Some or all pigs in five litters developed an exudative dermatitis which usually resulted in death of the animal. Except for its association with ration treatment no cause of the condition was determined.

209. VALUE OF ENZYME SUPPLEMENTS FOR RUMINANTS AS MEASURED BY FEEDLOT PERFORMANCE OF FATTENING LAMBS AND *IN VITRO* STUDIES. Brent Theurer, Walter Woods and Wise Burroughs, *Iowa State University, Ames.*

Four feeding trials were conducted with crude enzyme preparations added to dry corn rations. A bacterial enzyme preparation, Agrozyme, was fed at the rate of 1.5, 3 and 6 gm. per lamb daily. Ficin, a proteolytic enzyme preparation of plant origin, was fed at the rate of 5, 10 and 20 mg. per lamb daily. Addition of the enzyme supplements to various rations did not improve feed consumption, rate of gain or feed conversion. Values for carcass grade and dressing percent were similar for the control and enzyme supplemented lambs. *In vitro* studies with Ficin and a concentrate of Agrozyme maintained in rumen fluid under artificial rumen conditions indicated that most of the proteolytic activity of these enzyme preparations was lost in the first 2 or 3 hours of the fermentation period. A decrease in proteolytic activity was not noted when the enzyme preparations were maintained in autoclaved rumen fluid. Subjecting the enzyme preparations (in rumen fluid) to acidic conditions (pH 2.5) for 15 to 20 minutes resulted in a loss of more than 80% of the proteolytic activity. Raising the pH to 7.0 after acid treatment and maintaining this pH for 6 hours did not aid in recovery of the lost activity.

210. VALUE OF AUREOMYCIN, TYLOSIN, ZINC BACITRACIN AND PENICILLIN AS RATION ADDITIVES FOR SWINE. D. M. Thrasher and Sam L. Hansard, *Louisiana State University, Baton Rouge.*

Seventy-two weanling pigs were divided equally among 12 concrete drylots and were fed a corn-soy basal ration for 98 days with the following additions per ton of complete feed: lots 1 and 7, none; 2 and 8, 40 gm. Aureomycin; 3 and 9, 40 gm. tylosin; 4 and 10, 20 gm. tylosin; 5 and 11, 20 gm. Zn bacitracin; 6 and 12, 15 gm. Zn bacitracin, plus 5 gm. penicillin. When each lot averaged 100 lb. the protein content of the ration was reduced to 13%, and the antibiotic level was reduced by one-half. After 42 days the following observations were made. All ration additives significantly increased rate of gain ($P<.01$) and increased feed intake. Pigs fed tylosin gained 33% faster than controls. Tylosin and Zn bacitracin materially improved feed conversion, 6.4 and 5.4%, respectively. At the end of the study, the following results were obtained. Rate of gain was increased 8.4% by Aureomycin ($P<.05$) and 15% by tylosin ($P<.01$). Zinc bacitracin plus penicillin increased rate of gain 7.6%, approaching significance at the 5% level. Throughout the test, agreement between replicate lots was close, and performance of pigs on the two levels of tylosin was almost identical. Feed:gain ratios ranged from 3.24 for tylosin to 3.38 for Aureomycin.

211. ADDITION OF TALLOW TO SWINE RATIONS CONTAINING THREE LEVELS OF PROTEIN. D. M. Thrasher, A. M. Mullins, Sam L. Hansard, Paul B. Brown and R. F. Boulware, *Louisiana State University, Baton Rouge.*

Sixty weanling pigs were divided equally among six concrete drylots and fed during winter months corn-soy rations containing 12, 15 and 18% protein with and without 10% stabilized tallow. Ration protein content was reduced 2 percentage points at 100 lb. average pig weight. Pigs were removed individually at weekly intervals when weighing at least 200 lb. and were slaughtered for carcass cutout information. Analysis of the gain data showed a highly significant sex-fat-protein interaction. Rations containing tallow produced a highly significant increase in rate of gain among gilts but not among barrows. Tallow reduced the feed required per 100 lb. of gain from 15 to 23%. Pigs fed 15 and 18% protein rations gained 22% faster than those receiving 12% protein, which was highly significant. The difference in rate of gain between the 15 and 18% levels was not significant. Rations containing tallow produced a highly significant increase in carcass backfat thickness but did not significantly affect the percent of total fat trim, loin eye area, percent lean cuts or the areal lean:fat ratio in the face of the untrimmed ham. The 12% protein level reduced ($P<.01$) loin eye area and percent lean cuts, and increased ($P<.01$) backfat thickness and percent fat trim. There was no significant difference in carcass meatiness between the 15 and 18% protein levels when measured by the above criteria.

212. EFFECT OF DIETARY NITRATE ON GROWTH AND REPRODUCTIVE PERFORMANCE OF SWINE. J. T. Tollett, D. E. Becker, A. H. Jensen and S. W. Terrill, *University of Illinois, Urbana.*

Four trials were conducted. With growing pigs, three trials were undertaken to study the effects of levels and source of nitrate, and the influence of vitamin A on nitrate toxicity. Six lots of seven pigs each were fed a 16% corn-soybean meal basal which had 0, 0.61, 1.23, 1.84, 2.4 and 3.17% NO_3 added as KNO_3. Nitrate additions above 1.84% significantly depressed gains ($P<.05$) and above 2.4%, the depression was highly significant ($P<.01$). Trial 2 was conducted to determine whether nitrate or potassium was involved in the growth depression. Four lots of eight pigs each received a 16% corn-soybean meal basal, 5% KNO_3 (3.17% NO_3 + 1.93% K), 3.68% KCl (1.93% K), 4.35% Na NO_3 (3.17% NO_3) diet. Sodium nitrate and KNO_3 caused a highly significant depression in gain ($P<.01$) whereas KCl had no effect. Trial 3 involved eight lots of six pigs each which received various levels of NO_3 (0, 0.61, 1.84, and 3.17%) and various levels of vitamin A (0, 1500, 3600 IU of vitamin A per pound). In all cases regardless of vitamin A level, the growth of pigs receiving 3.17% NO_3 was significantly depressed ($P<.01$) whereas the methemoglobin level was increased. Trial 4, involving 24 gilts, was undertaken to study the effect of nitrate on reproductive performance. Growth was significantly depressed ($P<.01$), but no differences were obtained on corpora lutea number, percent implantation, ovary weight, embryo weight, placental weight or thyroid weight.

213. EFFECT OF FEED ADDITIVES AND FEED PREPARATION ON THE RESPONSE OF FEEDER LAMBS. W. J. Tyznik, J. H. Cline and J. K. Judy, *Ohio State University, Columbus.*

In experiments conducted in 1958–1959, 388 native Ohio feeder lambs were randomly allotted by weight. A ration comprised of 50% alfalfa hay, 40% ground shelled yellow corn, 10% soybean oil meal was self-fed as pellets and as meal. Two lots were hand-fed a ration of long hay, shelled corn and soybean oil meal. The effect of stilbestrol (3 mg. implant per lamb), antibiotic (10 mg. per pound of feed), and a combination of stilbestrol and antibiotic was studied under all ration treatments. Data show that pelleting, self feeding, antibiotic, stilbestrol and a combination of antibiotic and stilbestrol increased rate of gain. All treatments except self-feeding lowered feed cost.

214. STUDIES OF COPPER UTILIZATION BY THE BABY PIG. D. E. Ullrey, E. R. Miller, O. A. Thompson, C. L. Zutaut, D. A. Schmidt, H. D. Ritchie, J. A. Hoefer and R. W. Luecke, *Michigan State University, East Lansing.*

Two experiments have been conducted, involving 31 pigs, in which levels of 6, 16 and 106 parts of copper per million parts of dry diet have been evaluated. Average daily gain, feed per pound of gain and the formed elements of the blood were not significantly effected by treatment. Copper intake of 16 ppm. or higher increased the percent saturation of transferrin, albumin/globulin ratio and serum copper and iron concentration as compared with the 6 ppm. level. The 16 and 106 ppm. levels were not significantly different in this respect. Liver copper and iron concentration increased as dietary copper intake increased.

215. DEMONSTRATION OF A FACTOR IN ALFALFA HAY REQUIRED FOR EGG PRODUCTION BY THE STOMACH WORM OF SHEEP. R. L. Vetter, A. L. Pope, A. C. Todd and W. G. Hoekstra, *University of Wisconsin, Madison.*

It was demonstrated earlier that feeding lambs a pelleted semi-purified diet greatly reduced stomach worm egg production and that this effect could be reversed upon switching the lambs to a natural diet. In three trials, lambs were experimentally infected with *Haemonchus contortus* larvae and uniformly allotted to treatments on basis of fecal egg counts and hemoglobin levels. The first trial tested various modifications of the semi-purified diet in loose form and the relative effect when the pelleted semi-purified diet was combined with natural rations. A simplified basal ration produced a similar inhibitory effect on parasite egg production which was counteracted by hay or a factor in hay. The second trial tested the effects on parasite egg production of various extracts and residues from alfalfa hay when fed to parasitized lambs. A basal ration was fed to lower or inhibit egg production in all groups. When switched to the test diets, some increase in fecal egg counts occurred with lambs fed the residue of alfalfa hay which had been subjected to either water or "Skelly-B"-ethanol extraction. Feeding a "crude fiber" preparation or a water extract of alfalfa, or a rumen fluid concentrate from sheep fed hay did not stimulate parasite egg production. Likewise, in the final trial, addition of alfalfa ash to the basal diet did not alleviate the inhibitory effect; however, a stimulatory response was produced by an alkaline extract of alfalfa hay.

216. VALUE OF ADDED ENZYME PREPARATIONS IN BEEF CATTLE RATIONS. J. K. Ward, D. Richardson and W. S. Tsien, *Kansas State University, Manhattan.*

Three lots of 10 Hereford heifers each weighing about 466 lb. were fed a fattening ration of ground corn, sorghum silage, alfalfa hay, soybean oil meal plus minerals for 215 days. Treatments consisted of: (1) control; (2) 0.567 gm. amylolytic enzyme preparation per head daily; and (3) treatment 2 plus 1.362 gm. proteolytic enzyme preparation per head daily. Animals on treatment 3 consumed their feed more readily than the others. Average daily gain at the end of 28 days was 1.73, 1.89 and 2.36 lb., respectively. Rate of gain for treatments 2 and 3 declined during the remainder of the trial, gains for the period of 182–210 days being 1.63, 1.04 and 1.13 lb. per head per day, respectively. Daily gain for the 215-day period was 1.69, 1.52 and 1.60 lb., respectively, with differences non significant statistically. Pounds of feed required per 100 lb. gain were 913, 981 and 962, respectively. There were no significant differences in total millimols per 100 ml. of acetic, propionic and butyric acids in rumen fluid or in the proportion of these acids. Two fistulated Shorthorn steers were fed a ration consisting of ground corn, soybean oil meal, alfalfa hay and prairie hay with propor-

tions being about 60% concentrates and 40% roughage. Treatments consisted of amylolytic and proteolytic enzyme preparations given individually and in combination to each animal at levels shown in treatment 3 above. There were no apparent differences in either the level of rumen fluid volatile fatty acids or in the proportions of acetic, propionic or butyric acids.

217. VOLATILE FATTY ACID PRODUCTION IN THE GASTROINTESTINAL TRACT OF BEEF CATTLE. J. K. Ward, D. Richardson and W. S. Tsien, *Kansas State University, Manhattan.*

Four Hereford heifers from each of three lots of ten were selected on the basis of uniformity of finish and conformation to study volatile fatty acid levels and proportions in samples taken from various portions of the gastrointestinal tract. The heifers averaged 798 lb. each, after full feeding 215 days. The average daily ration (lb.) consisted of ground corn 10.2, sorghum silage 9.8, alfalfa hay 1.0, soybean oil meal 1.0 and salt plus bonemeal. Samples taken immediately after slaughter were quick frozen and stored until analyzed. Portions of the gastrointestinal tract sampled were the rumen, abomasum, jejunum, caecum and colon. Average levels of volatile fatty acids in millimols per 100 ml. of sample were 11.902, 1.292, 1.943, 12.155 and 11.214, respectively. Traces of formic and lactic acids were evident in some rumen samples. Samples from the abomasum and jejunum also showed substantial amounts of formic and lactic acids. Slight amounts of formic and substantial amounts of lactic acids were observed in the caecum and colon samples. Relatively small amounts of acetic and propionic acids were found in the jejunum with proportionately greater amounts of butyric and lactic acids.

218. RESPONSE OF DAIRY CALVES TO MILK REPLACERS CONTAINING ADDED FAT. R. G. Warner and J. K. Loosli, *Cornell University, Ithaca, New York.*

One hundred and twenty 3-day old Holstein heifer calves were allotted to five replicates of an experiment involving four milk-feeding treatments, viz. (1) 180 lb. whole milk; (2) 25 lb. of a 2% fat milk replacer; (3) 20 lb. of (2) + 4.5 lb. coconut oil + 0.5 lb. crude soya lecithin and (4) 20 lb. of (2) + 5 lb. of lard oil including a commercial emulsifier. Fats were melted and mixed into the dry ingredients. Diets (1), (3) and (4) were calculated to contain identical amounts of digestible energy. Diets (2), (3) and (4) were mixed 1 to 9 with water before feeding. All diets were fed on an identical dry matter basis for 28 days. An open-formula commercial calf-starter was offered free choice to a maximum of 4 lb. per day. Hay was fed free choice. Average daily gains to seven weeks of age were (1) 1.07; (2) 1.05; (3) 1.03; and (4) 0.95 lb. The differences were not significant. Total starter consumption in lb. were, respectively, (1) 77.9; (2) 87.4; (3) 78.7; and (4) 75.4. Consumption of (2) was significantly ($P<0.05$) greater than the others. Hay consumption was low and similar for all groups. Although (2) contained less digestible energy than the other diets, calves grew as fast as a result of increased starter consumption. These data show that if a gain of 1 lb. per day is all that is required to seven weeks of age, there is little value in adding fat to the milk replacer. The gains of all calves were adequate for rearing herd replacements.

219. AVAILABILITY OF THE PHOSPHORUS IN VARIOUS SOURCES FOR DAIRY CALVES. R. A. Wentworth, M. B. Wise and S. E. Smith, *Cornell University, Ithaca, New York.*

The availability of the phosphorus in dicalcium phosphate, a defluorinated rock phosphate, Curacao Island phosphate and soft phosphate with colloidal clay was studied in two feeding trials, each involving 25 Holstein heifer calves. Beginning at 12 weeks of age the calves were individually fed (*ad libitum*) a semi-purified basal

ration containing an average of 0.10% P. One group of five calves received only the basal ration, while four other groups of five animals each received the basal ration to which one of the above supplements was added to bring the total phosphorus up to 0.19%. Trial I ran for 56 days and Trial II for 99 days. Bone growth was measured by an autoradiographic technique. Feed consumption and body weight gains among supplemented calves were not significantly different in Trial I but in Trial II calves receiving soft phosphate consumed less and gained less than the calves on the other supplements. Average terminal serum inorganic phosphorus in mg. % of calves fed the supplements in the order listed above were, respectively: Trial I, 6.87, 6.44, 6.18 and 5.87; Trial II, 5.26, 4.13, 4.12 and 3.07. Ribs of calves fed soft phosphate grew less and had a significantly lower ash and phosphorus content than those of calves fed other supplements. Other criteria used were serum phosphatase, femur growth and feed conversion values. Considering both trials, the phosphorus of dicalcium phosphate was most highly available, followed closely by the defluorinated rock phosphate and Curacao Island phosphate and least available in soft phosphate.

220. OVINE RATION EVALUATION SYSTEMS AS INFLUENCED BY RATION COMPOSITION. T. W. White, W. H. Pfander and W. C. Ellis, *University of Missouri, Columbia.*

Seventy-six lambs were used in two trials to compare ration evaluation systems in rations containing various cellulose and nitrogen levels. A 3 x 3 factorial design was used in Trial I with 13.87, 16.11 and 20.42% cellulose levels being combined with 1.78, 2.12 and 2.45% nitrogen levels to form the rations. In Trial II a 2 x 2 factorial design was used with 13.73 and 19.73% cellulose levels being combined with 1.98 and 2.29% nitrogen levels to form the rations. A high correlation was found between dry matter and energy digested ($r=+0.87$) and between organic matter and energy digested ($r=+0.88$). Regression equations for estimating energy digested (Y) from dry matter (X_1) or organic matter digested (X_2) are $Y=-243.7+5.14X_1$ and $Y=-284.4+5.37X_2$, respectively. Total digestible nutrients, digestible energy and "metabolizable energy" were each correlated with average daily gain ($r=+0.54$, $+0.61$ and $+0.44$, respectively).

221.

222. EFFECTS OF THE TOTAL FLOOR SPACE ALLOCATION FOR SWINE DURING THE FINISHING PERIOD. F. C. Wingert and C. B. Knodt, *Cargill-Nutrena Research Farm, Elk River, Minnesota.*

A pilot trial was conducted between February 4 and March 3, 1959. Swine allocated 13 sq. ft. of total floor space per head during the finishing period gained 11.3% faster on 6.5% less feed per unit of gain than a similar group provided 9 sq. ft. A second trial covering the 28-day period from April 7 through May 5, 1959, was conducted with groups of 49 head each. A complete, pelleted diet was fed from an average initial weight of approximately 146 lb. to an average final weight of approximately 200 lb. in pens providing 9.8, 14.7 and 19.6 sq. ft. of total floor space per pig respectively. Average daily gain, pounds of feed per cwt. of gain, feed costs per cwt. of gain, number of pigs unable to walk at the end of the trial and the number seriously lame were as follows: 9.8 sq. ft.—1.61, 428.7, $12.95, 2, 3; 14.7 sq. ft.—2.01, 357.1, $10.78, 0, 1; and 19.6 sq. ft.—2.11, 339.3, $10.24, 0, 1. Based on a cost of $60.40 per ton for the complete, pelleted diet, actual sale prices for the swine and 3 groups of swine per year over a 15-year pen life, the space allocation of 14.7 sq. ft. per pig reduced feed costs $2822.45 and injury and lameness losses $4973.85 when contrasted with the allocation of 9.8 sq. ft. The allocation of 19.6 sq. ft. per head reduced feed costs $702.45 when contrasted with 14.7 sq. ft.

223. INFLUENCE OF FEEDING A GROUND SHELLED CORN-UREA DIET WITH AND WITHOUT ROUGHAGE ON GROWING-FINISHING BEEF STEERS. M. B. Wise, G. Matrone, T. N. Blumer and E. R. Barrick, *North Carolina Agricultural Experiment Station, Raleigh.*

Thirty-four Hereford calves were used in two experiments to investigate the feeding of all-concentrate rations to cattle. A basal diet was used containing 95.1% ground shelled corn, 1.0% urea, 2.0% cottonseed oil, 0.7% $CaCO_3$, 0.2% defluorinated phosphate, 0.1% vitamin A & D concentrate, and 0.9% trace mineralized NaCl. Calves were individually fed (*ad libitum*) in concrete floored pens with no bedding. In a preliminary experiment, calves (five per treatment) averaging 530 lb. were fed for 99 days. Treatments, daily gain in lb., daily feed intake in lb. and feed/lb. gain were, respectively: *Basal,* 1.89, 11.0 and 5.8; *Basal + 7% $NaHCO_3$ + 4% $KHCO_3$,* 0.72, 9.2 and 15.0. The surprising success with the basal diet stimulated a second study in which six calves per treatment averaging 425 lb. were fed for 119 days. Treatments with respective daily gain in lb., daily feed intake in lb. and feed/lb. gain were: *Basal,* 2.50, 12.5, 5.0; *Basal + 5% Na and K Acetate,* 2.24, 12.5, 5.6; *Basal + 2½#/hd/da of ground hay,* 2.57, 12.8 basal + 2½ hay, 5.0 basal + 1.0 hay; *Basal + 2½#/hd/da of long hay,* 2.50, 12.8 basal + 2.5 hay, 5.2 basal + 1.0 hay. Percentage fat, lean and bone in the 9–10–11 rib cut, rind thickness, number and also area of fat deposits in the ribeye muscle indicated a slightly higher finish among calves fed the basal alone compared to calves fed basal + hay. Calves fed Na and K acetate in their diet had the least finish. Digestive disturbances were not encountered excepting slight diarrhea among calves fed the diets containing the Na and K salts.

224. EFFECT OF ENERGY AND PROTEIN INTAKE UPON NUTRIENT DIGESTIBILITY AND REPRODUCTION IN EWES. P. L. Wright, A. L. Pope and P. H. Phillips, *University of Wisconsin, Madison.*

This experiment was conducted over a three-year period to compare various levels of energy and protein for gestating and lactating ewes. Forty bred whiteface ewes were randomly allotted, each year, into four lots. The ration for each lot was changed according to stage of production as follows: first 15 weeks of gestation, last 6 weeks of gestation, and first 8 weeks of lactation. Thus, rations varied from lot to lot and from period to period. The levels of energy and protein fed Lot I served as a positive control; Lot II corresponded to the nutrient requirements of ewes as set forth by the National Research Council in 1957; Lot III served as a negative energy control during late gestation and lactation; and Lot IV was the positive energy control. Digestion trials by the total collection method were conducted on each of the rations fed during the third year, representative ewes from each lot being used. All ewes gained in weight during gestation, Lots I and IV significantly more than Lot II and III. During lactation only Lot IV increased in weight; all other lots decreased. No significant differences were observed in wool production of the ewes or in birth weight or 14- or 28-day weight of the lambs. At 8 weeks the lambs of Lot III were significantly lighter than those of all other lots. By increasing the level of energy and/or protein it was possible to alter prepartum weights of bred ewes and to overcome the loss of weight during lactation. Varying the intake of these two nutrients in the ration of the ewes affected lamb production only after 8 weeks of lactation.

225. CALCIUM STUDIES WITH BABY PIGS. D. R. Zimmerman, V. C. Speer, D. V. Catron and V. W. Hays, *Iowa State University, Ames.*

Three experiments, each involving 16 individually-fed pigs, and one experiment utilizing 60 group-fed pigs (4 per pen), were conducted to investigate the influence of various Ca (calcium) and P (phosphorus) levels in high milk product rations (25% dried skim milk equivalent) on performance of pigs 2–6 weeks of age. Ca levels

ranging from 0.52 to 1.05% were used in combination with either 0.52 or 0.70% P. In general, rations with more than approximately 0.8% Ca caused a growth depression and in some cases adversely affected the utilization of feed. However, bone calcification, estimated by ash content of surgically removed metatarsal bones and bone optical densities from radiographs, increased with each added increment of Ca in two of the three individual-feeding experiments. In general, 0.52% Ca was inadequate for maximum growth rate and efficiency of feed utilization, while 0.70% Ca was adequate. Serum chlortetracycline concentrations were observed to decrease linearly with increasing Ca intakes; however, this observed effect was not responsible for the growth depression of high Ca intakes. High Ca intakes depressed growth in the presence or absence of chlortetracycline in the ration. In one experiment, where Ca balance was determined on pigs 3–4 weeks of age, the total retention of Ca was made maximal with a ration containing 0.88% Ca.

226. COMPARATIVE DIGESTIBILITY OF NUTRIENTS BY CATTLE AND SHEEP, R. A. Alexander, J. F. Hentges, Jr. and J. T. McCall, *Florida Agricultural Experiment Station, Gainesville.*

In a series of digestion trials, sheep and cattle were maintained in the same environment and fed 19 different rations—two concentrate mixtures (flaked and pelleted), two of oat silage, four of corn silage, and 11 of coastal bermudagrass hay plus trace mineralized salt and defluorinated phosphate fed free-choice. There was a highly significant ($P<0.01$) correlation between the digestibility of dry matter (0.939), protein (0.824), and energy (0.919) by sheep and cattle when the digestion coefficients of all 19 rations were combined. There were no significant differences in nutrient digestibility between one-year-old wethers and one-year-old steers. There were no significant differences between these wethers and mature cows fed two treatments of oat silage or high quality pelleted and long coastal bermudagrass hay from grass fertilized with 200 lb. nitrogen/acre. With lower quality coastal bermudagrass hay (fall harvested with 50 and 100 lb. nitrogen/acre) the one-year-old wethers digested protein and energy significantly ($P<0.01$) better than the mature cows. Another group of one-year-old wethers were compared with yearling steers fed four treatments of corn silage and high quality coastal bermudagrass hay in pellet, finely ground and long forms. The only significant difference was in digestibility of protein ($P<0.01$) in favor of the yearling steers.

227. MILK AND FORAGE CONSUMPTION, GROWTH, CARCASS CHARACTERISTICS AND PARASITISM OF EARLY- *VS.* LATE-WEANED LAMBS ON WINTER TEMPORARY PASTURES. D. M. Baird, H. C. McCampbell, W. E. Neville, H. Ciordia, W. E. Bizzell and O. E. Sell, *Georgia Experiment Station, USDA, ARS, Animal Disease and Parasite Res. Div., Experiment.*

As lambs were born, they were allotted on the basis of single or twin birth, sire and sex into winter temporary pastures of wheat and ryegrass. No creep was fed. The 20 lambs in Lot 1 remained with their dams until marketed at 90 lb. The 22 lambs in Lot 2 were weaned at 45 lb. at an average age of 76 days. Twenty-four hour milk consumption was obtained for all lambs every two weeks. Forage intake and digestibility were determined three times by the chromogen-chromic oxide method. Periodic pasture clippings were examined to determine the succession of parasite larvae. Fecal egg counts and post-mortem worm counts were made to determine extent of parasitism. ADG were 0.57 and 0.51 lb. ($P<.05$) for Lots 1 and 2 and the average ages of the two groups when marketed were 149 and 161 days, respectively. Slaughter and carcass grades were not significantly different between lots. On the average, single lambs consumed 2.56 lb. forage D.M. per cwt. and twins, 1.99 lb. Ewes with single lambs consumed 2.07 lb. D.M. per cwt. *vs.* 2.50 lb.

per ewe with twin lambs. Early weaning did not stimulate forage consumption of lambs. Correlations of milk consumption with ADG to 45 lb. and 120-day weights were .554** and .453*, respectively, for all lambs adjusted for treatment, sex, sire and type of birth. Ewes with twins gave 33.6% more milk than ewes with single lambs. By 15 weeks most milk production had ceased. Early-weaned lambs had 46% less worms at slaughter than late-weaned lambs, 764 *vs.* 1,407. Larval recovery from pasture clippings was reduced by rain, low temperature and forage height.

228. PELLETED VS. NON-PELLETED CREEP FEEDING AND STILBESTROL IMPLANTATION OF EARLY-WEANED LAMBS ON WINTER TEMPORARY PASTURE. D. M. Baird, H. C. McCampbell and O. E. Sell, *Georgia Experiment Station, Experiment.*

Two similar tests were conducted over a two-year period with early-weaned spring lambs grazing winter temporary pastures. At birth, the lambs were allotted to treatments on the basis of single or twin birth, sire and sex. Lambs were weaned at 45 lb. and slaughtered at 90 lb. Treatments and ADG, adjusted for ram, sex and type of birth for the first year were: (1) Shelled corn creep, 0.53; (2) creep mixture, 0.58; (3) pelleted creep mixture, 0.59; and (4) shelled corn creep + 3 mg. stilbestrol implant at two weeks, 0.53 lb. Lots 2 and 3 gained significantly faster ($P<.05$) than the other two lots. Carcass grades of Lot 2 were over one-third grade higher ($P<.05$) than Lot 4. Treatments and adjusted ADG for the second year were: (1) Pasture only, 0.49; (2) mash creep, 0.57; (3) pelleted creep, 0.57; and (4) 3 + 3 mg. stilbestrol implant at 45 lb., 0.59 lb. Lot 1 gained significantly slower ($P<.01$) than the other lots. Death losses from overeating, although the lambs were vaccinated and fed antibiotic, were 9, 21 and 9%, respectively, for the grain-fed lots 2, 3 and 4. Implantation resulted in loss of one lamb in Lot 4. Carcass grades of Lot 1 were approximately one-half grade lower ($P<.05$) than the fed Lots 2, 3 and 4. Postmortem worm counts were 764, 171, 826 and 953 for Lots 1–4, respectively. Pelleting a highly palatable creep ration containing 10% sugar did not increase consumption. Implantation of 3 mg. stilbestrol at 45 lb. or approximately 10 weeks of age produced less side effects than at two weeks; however, there were no significant results by implanting this age lamb.

229. CHANGES IN THE ESTIMATED NUTRITIVE VALUE OF ALFALFA, BROMEGRASS, LADINO, AND RED CLOVER DUE TO STAGE OF MATURITY AND YEAR. B. R. Baumgardt and Dale Smith, *University of Wisconsin, Madison.*

The digestible dry matter of alfalfa, bromegrass, an alfalfa-bromegrass mixture, red clover, and ladino clover, each harvested at six stages of maturity during the spring and summer growth periods of 1955 and 1956, was estimated from *in vitro* cellulose digestion by rumen microorganisms. The six stages of maturity were selected on the basis of the maturity of the alfalfa as follows: I, succulent; II, pre-bud; III, mid-bud; IV, 1/10 bloom; V, full bloom; VI, green seed pod. Estimated digestible dry matter (EDDM) values of the spring growth, averaged over all species, were 72.0, 69.5, 66.2, 63.1, 59.4, and 60.4 (av., 65.1) in 1955; and 81.0, 79.4, 74.1, 70.5, 68.3, and 62.9 (av., 72.7) in 1956 for the six stages of maturity, respectively. Stage I was reached on April 25 in 1955 but not until May 16 in 1956. On the average, the EDDM of the spring growth of the forages declined from 76.5 to 61.6 (av., 68.9) while that of the summer re-growth of the forages dropped from 73.8 to 65.1 (av., 69.1). Alfalfa and the alfalfa-bromegrass mixture responded more closely to reported decreases in DDM with increasing date of cutting. Ladino clover was consistently higher in EDDM than the other forages but showed a similar decline with advance in maturity.

230. PASTURE MIXTURES FOR BEEF CATTLE. Frank Buck, W. C. Templeton, W. P. Garrigus and E. N. Fergus, *University of Kentucky, Lexington.*

A 4-year grazing experiment to study three pasture mixtures; Kentucky bluegrass—white clover, smooth bromegrass—ladino clover, and Kentucky bluegrass—birdsfoot trefoil has been concluded. The factors used to evaluate the mixtures were daily gain, days grazing, beef per acre and carcass finish. Three hundred twenty good to choice yearling Hereford steers, wintered to gain 1.0 lb. per day, were used. No supplemental feed was given on pasture. The experiment was of split block design with four replications of each mixture. Two of the four replications were continuously grazed while each of the other two were divided into three sub-plots and grazed rotationally. Grazing was on a "put and take" basis with two "tester" steers randomly allotted each pasture. The Bluegrass—white clover mixture produced 382 lb. of beef per acre, 231 steer days grazing, 165 lb. daily gain and standard carcass grade. The bromegrass—ladino clover mixture produced 369 lb. of beef per acre, 214 steer days grazing, 1.72 lb. daily gain and standard carcass grade. The Bluegrass—birdsfoot trefoil mixture produced 287 lb. of beef per acre, 192 steer days grazing, 1.52 lb. daily gain and standard carcass grade. The average daily gain, slaughter grade, steer grazing days, systems of grazing were not significantly different for the three mixtures. The beef produced per acre was significantly different for each mixture.

231. PASTURES AND GRAZING METHODS FOR SPRING LAMB PRODUCTION. R. C. Carter, C. Y. Ward, F. S. McClaugherty, J. S. Copenhaver and R. E. Blaser, *Virginia Agricultural Experiment Station, Blacksburg and Glade Spring.*

Comparisons of permanent bluegrass white clover with orchard grass ladino clover pastures and of rotational with continuous grazing of bluegrass-clover were made at two stations over a three year period, 1957–59. Ewes and lambs were used as tester animals with yearling cattle and dry ewes as grazers to consume surplus forage. Average daily gains of the tester lambs, adjusted by least squares for year, sex, twinning, age of dam and breed, were 0.62 lb./day for continuous bluegrass, 0.55 for rotational bluegrass and 0.49 for orchard-ladino at the main station at Blacksburg, and 0.70, 0.61, and 0.50 for the respective pastures at the Southwest Station at Glade Spring. Differences among pastures in daily gains were highly significant. Live slaughter grades ranked similar to daily gains but not all differences were significant. Average stocking rate, in terms of ewes per acre (cattle and lambs converted to ewe equivalents), were 6.1 on continuous bluegrass, 6.6 on rotational bluegrass and 7.7 on orchard-ladino at Blacksburg; and 5.6, 8.2, and 8.5 respectively at Glade Spring.

232. PREDICTION OF THE NUTRITIVE VALUE INDEX OF CHOPPED AND GROUND FORAGES BY AN *IN VITRO* METHOD. E. Donefer, L. E. Lloyd and E. W. Crampton, *Macdonald College (McGill University) Canada.*

Using the *in vitro* rumen fermentation method previously described (J. Animal Sci. 19:545, 1960), 12-hour cellulose digestion was determined for 32 forages for which the Nutritive Value Index (N.V.I.) had been obtained in *in vitro* sheep trials. Eleven of these forages were harvested and fed in a chopped form at the Canada Department of Agriculture Experimental Farm at Swift Current, Saskatchewan (Can. J. Plant Sci. 39:417, 1959), with samples supplied to our laboratory for *in vitro* analysis. Of the remaining 21 forages fed in our laboratory, 5 were tested in the chopped form, 6 in the ground form and 10 in both the chopped and ground forms. This provided a total of 42 *in vitro-in vivo* comparisons, 26 for chopped and 16 for

ground forages. Separate regression analyses were required for chopped and for ground forages since the N.V.I. of a forage may vary with the physical form in which it is fed, although the *in vitro* cellulose digestion of that forage, based in all cases on a finely ground sample, provides only a single value. The 12-hour *in vitro* cellulose digestion (X) was found to be highly correlated ($P=0.01$) with the N.V.I. of forages fed either chopped ($r=0.91$) or ground ($r=0.87$). Since the regression coefficients (b) for both physical forms were found to be homogenous ($P=0.01$) by appropriate statistical analysis, they were pooled to give a single value. Prediction equations for the N.V.I. of chopped and ground forages are, respectively, $\hat{Y}=-3.5+1.23X$ and $\hat{Y}=7.4+1.23X$.

233. EFFECT OF NITRATES AND NITRITES UPON FORAGE UTILIZATION BY RUMEN MICROORGANISMS *IN VITRO* AND UPON RATION DIGESTIBILITY BY LAMBS. O. Glen Hall, C. D. Gaddy and C. S. Hobbs, *University of Tennessee, Knoxville.*

Washed suspensions of rumen microorganisms were used in replicated experiments to determine the effects of $NaNO_3$ and $NaNO_2$ upon cellulose digestion by rumen microbes *in vitro*. Additions of $NaNO_3$ of 2.8 mg. and above to fermentation tubes containing Solka-floc markedly decreased ($P<.01$) *in vitro* cellulose digestion. Levels of $NaNO_2$ of 1.4 mg. and above completely inhibited *in vitro* microbial cellulose digestion. In a second series of experiments, $NaNO_3$ was added to fermentation flasks containing 0.4 gm. of non-nitrated young Sudan forage at levels from 0 to 55 mg. per flask. Forage dry matter digestion by washed rumen microbes was reduced by more than one-half ($P<.01$) when 13 mg. or more of $NaNO_3$ were added. Forage dry matter digested in control flasks (no added nitrate) was 66.2% as compared to 16.6% in flasks to which 25 mg. of $NaNO_3$ had been added. Evidence was obtained which indicated that the poorer utilization of a heavily nitrated young Sudan forage (120 lb. N/acre) by rumen microbes *in vitro* may be due to the presence of nitrates and/or nitrites in the forage. Twelve wether lambs were used in a digestion trial to determine the effects of feeding 2.5 gm. and 5.0 mg. of $NaNO_3$ per head daily upon dry matter and cellulose digestibility of a ground orchardgrass hay. Results of this trial showed that wether lambs fed 2.5 mg. of $NaNO_3$ per head daily digested significantly less hay dry matter ($P<.10$) and less cellulose ($P<.01$) than did the control lambs. Lambs fed the higher level of $NaNO_3$ digested the hay dry matter and cellulose equally as well as did the control lambs, however.

233a. PERFORMANCE OF HEREFORD STEERS ON IRRIGATED PASTURES. Lorin E. Harris, Milo L. Dew and George Q. Bateman, *Utah State University, Logan.*

Eighty Hereford yearling steers were segregated by weight and allotted at random to four treatments: pasture only; pasture plus stilbestrol implant of 24 mg.; pasture plus alfalfa hay; and, pasture plus alfalfa hay plus stilbestrol implant. Steers received water, salt and a phosphorus mineral supplement *ad libitum*. Pasture consisted of Ranger alfalfa (3 lb. per acre), Ladino clover (2), orchard grass (3), smooth brome grass (4), red clover (3), and tall oat grass (4). Pasture season was 159 days. The grazing started when the pasture was about 4 in. high (April 28). Steers were rotationally grazed (moved about every one to two days) in such a manner that pasture was 30 to 35 days old except for the first grazing. Pasture matured in stepwise fashion. The gain per acre was 974, 1210, 1147 and 1414 lb., respectively. The daily gain per steer was 1.36, 1.68, 1.53 and 1.88 lb., respectively. Hay eaten *ad libitum* did not control bloat; however, when fed just before turning animals into a new pasture it did control bloat. Dry matter produced per acre of pasture was 9,624 lb. and digestible energy was 11,806 therms.

234. HIGH ROUGHAGE AND COTTONSEED MIXTURES FOR FATTENING CALVES. W. B. Anthony, R. R. Harris and J. G. Starling, *Auburn University, Auburn, Alabama.*

Conventional feed lot tests and balance trials were conducted to compare high and low roughage mixtures and protein sources in diets for fattening calves. Blended mixtures containing either 0, 10, or 30% of coastal Bermudagrass hay were compared. Ground cottonseed was compared as a protein source with cottonseed meal and with a mixture of cottonseed meal and soybean meal. Identity of test diets in the feed lot were 30% hay, Ration I; 10% hay, Ration II; cottonseed, Ration III; and no hay and CSM-SBM protein, Ration IV. Each of the test diets was fed to a group of eight Medium to Good feeder steer calves and a group of eight Medium to Good feeder heifer calves. The diets were full-fed 200 days. In the balance trials a 4 x 4 latin square design was used and test animals were eight Good feeder steer calves. Average daily gains from rations I, II, III, and IV were 2.04, 2.14, 1.91, and 1.96 lb., respectively. In the same order, amounts of feed per cwt. of gain were 988, 964, 923, and 966 lb. The differences in daily gain and feed per cwt. of gain were not statistically significant. All animals were finished to essentially the same degree as evidenced by the fact that all carcasses graded U.S.D.A. Good. The mixture containing 30% of hay was equal to the more complex, high-grain mixture for fattening calves to a Good slaughter finish. Cottonseed was an effective substitute for CSM and a mixture of CSM-SBM. Nutrient absorption was highest for ration IV, but the advantage was small. Daily feed intake was highest on the high roughage ration. The starch content of ration IV was about 12% higher than that of ration I.

235. EARLY WEANING OF LAMBS: A COMPARISON OF THE PERFORMANCE OF LAMBS WEANED AT SIX AND NINE WEEKS OF AGE. F. C. Hinds, M. E. Mansfield and J. M. Lewis, *University of Illinois, Dixon Springs Experiment Station.*

This study was conducted to determine how early lambs maintained under drylot conditions could be weaned. Previous work at this Station has indicated that lambs weaned as early as 9 weeks of age experienced no great difficulty in adjustment. All of the lambs were sired by Suffolk rams of similar background and performance. Lambs within the same period of lambing were randomly assigned to one of two outcome groups. One group was weaned on the Friday of the week they became 6 weeks of age and the other at 9 weeks. This continued until all of the lambs were weaned. Each of the four lots to be discussed contained 10 single lambs and 10 twin lambs all having weaning age in common. The ration fed was calculated to supply in excess all of the nutrients assumed to be required by a lamb weaned at 6 weeks. The information obtained on average daily gain and feed required per pound of gain indicates that lambs weaned at approximately 6 weeks perform as well as those weaned at 9 weeks. In fact, during similar periods of their lives, lambs weaned at 6 weeks performed as well or better than those weaned at 9 weeks. Death losses were not increased by weaning lambs at 6 weeks.

236. *IN VITRO* EVALUATION OF NITROGEN-FERTILIZED FORAGES AND THEIR EXTRACTS. L. L. Hopkins, Jr., C. D. Story and F. C. Daugherty, *Colorado State University, Fort Collins.*

Previous work at this station has indicated lower ($P<.01$) gains of heifer calves fed nitrogen-fertilized mountain meadow hay (90 lb. available N per acre) as compared with heifers fed non-fertilized meadow hay. Also, a comparison of the two hays in artificial rumen studies, using total gas production as a measure of microbial activity, has indicated reduced gas production from nitrogen-fertilized hay. Therefore, an attempt was made to concentrate and identify the factor or factors responsible for

this reduced gas production. Brome grass, orchard grass and alfalfa forages, fertilized with 0, 400 and 800 lb. of available nitrogen per acre (applied as NH_4NO_3) and from two widely separated locations, were fermented *in vitro*. In addition, these forages were extracted with various solvents and the extracts were added to *in vitro* fermentations. Repeated *in vitro* fermentations indicated that gas production decreased as the level of nitrogen fertilization of the forages increased. Ethanol (80%) extracts of the nitrogen-fertilized forages added to non-fertilized hay substrates showed a highly significant depression of gas production. *In vitro* fermentation of the ethanol extracted forages indicated almost complete removal of the inhibiting factor(s) from nitrogen-fertilized hay. The ethanol extracts were passed through ion exchange-resin columns and the eluate from the anion exchange resin was found to depress gas production from *in vitro* fermentation of non-fertilized forage. Further analysis of the eluate indicated that the factor was nitrate.

237. FACTORS CONTRIBUTING TO AND AFFECTING THE CELLULOSE DIGESTIBILITY OF PELLETED ROUGHAGE. J. R. Jahn and L. D. Kamstra, *South Dakota State College, Brookings.*

Seven groups of pellets were made from first and third stages of alfalfa-brome, western wheat, and little blue stem grass. Temperatures of 120°, 300°, and 435° F. were used in combination with pressures of 4,000, 10,000, and 16,000 p.s.i. in the formation of these pellets. Forty-eight hour *in vitro* digestions, X-ray diffraction studies, infra-red spectrophotometry analysis, polymerization measurements, "proximate" and lignin analysis were conducted, comparing the pelleted and unpelleted forage. The digestion trials indicate the improvement in digestibility was more pronounced with low quality or third stage forage at all temperature and pressure combinations. For example, an improvement of approximately 10% in the digestibility of third stage little blue stem (120° F.; 4,000 p.s.i.) was shown, compared to an improved digestion of only 3% for the first stage little blue stem (120° F.; 4,000 p.s.i.). The infra-red and X-ray diffractions studies showed a difference between pelleted and unpelleted but the complexity of the material made it difficult to determine the nature of the change. No appreciable differences were indicated in the results of the polymerization measurements or lignin and "proximate" analysis. It did not appear that pelleting *per se* could transform a low quality roughage into a high quality forage but pelleting a low quality roughage should improve its digestibility and intake somewhat.

238. PERENNIAL PASTURE STUDIES WITH EARLY WEANED LAMBS. R. M. Jordan and W. F. Wedin, *University of Minnesota, St. Paul and Agricultural Research Service, U. S. Department of Agriculture.*

Early-weaned lambs were used to evaluate methods of management for maximum lamb production on perennial pastures. Four treatments were involved: alfalfa-bromegrass pasture, 3-paddock rotational (3X); alfalfa-bromegrass pasture, 2-paddock rotational (2X); nitrogen-fertilized bromegrass pasture, 3-paddock rotational (3X); and alfalfa-bromegrass pasture, 3-paddock rotation (3X) plus self-feeding of grain. Treatments were replicated three times. No difference in ADG occurred between 2- and 3-paddock rotational pastures. However, carrying capacity and consequently lamb gain per acre was increased considerably by 3X management. Bromegrass (3X) had as much carrying capacity as alfalfa-bromegrass 3X during the early season; however, ADG were the lowest of any of the treatments during both years. Self-feeding of grain to early-weaned lambs on excellent alfalfa-bromegrass pasture increased carrying capacity and ADG tremendously and resulted in over 100% more pounds of lamb produced per acre. ADG (lb.) and total pounds lamb produced per acre in 1959 were: legume 3X, 0.29 and 632; legume 2X, 0.29 and 559; bromegrass 3X, 0.21 and 417; and legume-grain 3X, 0.41 and 1132 lb. In 1960 the ADG and

total pounds of lamb produced per acre were: legume 3X, 0.30 and 515.2; legume 2X, 0.32 and 428.8; bromegrass 3X, 0.27 and 454.2; and legume-grain 3X, 0.49 and 1336.2. In order to utilize productive pastures it is necessary either to cut 25–35% for hay in June, reduce grazing pressure by mid-July, or to commence grain feeding by mid-July.

239. RESTRICTED TIME GRAZING OF DRY EWES. R. M. Jordan and W. F. Wedin, *University of Minnesota, St. Paul, and Agricultural Research Service, U. S. Department of Agriculture.*

Grazing studies with dry ewes were conducted to study the effect of restricting grazing time per week on body weight gains during the grazing season, forage consumption, fleece weights and lamb production. Six pastures involving three different treatments were involved each year. Treatments were as follows: 14 ewes per acre grazed continuously; 7 ewes per acre grazed continuously; 14 ewes per acre grazed on a restricted-time basis. The "restricted ewes" were confined in small corrals in the pasture with access to shade, water and salt for 52 hours, graze 20, confined 28 and grazed 68 hours per week. Forage yields and consumption estimates are based on a combination of cage and swath samples from the pastures. Restricted-time grazing conserved forage, reduced ewe weights and extended the grazing season without adversely affecting either wool or lamb production. Assuming there was an equal amount of forage in all six pastures at initiation of the trial in 1959, swath samples taken 22 days later on June 6 indicate that there was only 675 lb. dry matter per acre available where continuous heavy grazing was practiced; 1397 lb. where 7 ewes per acre were grazed continuously; and 1185 lb. where 14 ewes per acre were grazed on a restricted-time basis. During both years ewes stocked light and grazed continuously gained most and the ewes grazed on a restricted-time basis lost the most.

240. PROTEIN REQUIRED BY EWES ON CORN SILAGE RATIONS. Melvin R. Karr and C. V. Ross, *University of Missouri, Columbia.*

Eighty southwest yearling ewes bred for late lambs grazed on blue-grass until January 10, then were dry-lot fed on corn silage (*ad. lib.*) plus graded levels of soybean oil meal. Soybean oil meal fed per ewe daily in lots 1, 2, and 3 was 0.42, 0.24 and 0.05 lb., respectively. After lambing all ewes and lambs were grazed together. Ewes on the two higher levels of soybean oil meal made significantly faster gains in dry lot ($P<.01$). They gave birth to heavier lambs and sheared heavier fleeces than ewes on the lowest level of soybean oil meal, but differences were not significant. Ewes on the lowest level of soybean oil meal were quite thin and began losing wool 6 to 7 weeks before parturition; but at the end of 10 weeks there was little difference in weights of lambs from ewes on different treatments. A previous experiment was repeated in Trial II. Sixty ewes grazed fescue until January 10, then were divided into two uniform groups and fed corn silage (*ad lib.*) plus protein supplements in dry lot. One group received 0.35 lb. soybean oil meal per ewe daily and the other a mixture of ground alfalfa hay and corn which furnished the equivalent in crude protein and energy to the soybean oil meal. Again all ewes produced excellent lambs. Difference in fleece weights, lamb birth weights and vigor were insignificant. Ground alfalfa hay plus corn appears as satisfactory for supplementing corn silage for wintering ewes as soybean oil meal.

241. CONDITIONED ALFALFA HAY FOR WINTERING BEEF CALVES. Conrad J. Kercher, Clarence F. Becker and Wilson P. Miskimins, *University of Wyoming, Laramie.*

Seventy-one Hereford calves which averaged 368 lb. were randomly divided into three groups of 18 and one group of 17 calves. Two lots of calves were wintered

for 140 days on either crimped alfalfa hay or conventionally harvested alfalfa hay. All calves were fed 5.6 lb. corn silage per day and alfalfa hay (*ad libitum*). Second-cutting and third-cutting alfalfa hay harvested by both methods were fed for 56 and 84 days, respectively. The second-cutting crimped alfalfa hay was harvested without rain damage. The calves fed this hay gained 1.05 lb. per day during the 56-day period compared with 1.00 lb. per day for the calves fed conventionally harvested second-cutting alfalfa, which received 0.14 and 0.13 in. rain on two consecutive days. This delayed baling by four days. These differences in gain were not significant ($P>.05$). The average hay consumption per day was 9.8 and 10.5 lb. per head for the crimped and conventionally harvested hay, respectively. The third-cutting alfalfa harvested by both methods was baled without rain damage. The calves fed the crimped third-cutting alfalfa gained 0.96 lb. per day during the 84-day period which was significantly less ($P<.05$) than the calves fed the conventionally harvested third-cutting alfalfa (1.06 lb./day). Average hay consumption was 7.6 and 8.8 lb. per head per day for the crimped and conventionally harvested alfalfa, respectively. The 140-day gains of the calves wintered on the alfalfa harvested by the two methods were not significantly different ($P>.05$). Calves fed crimped hay gained 0.99 lb. compared with 1.04 lb. per day for those fed conventionally harvested hay.

242. SYSTEMS OF MANAGING EWES AND LAMBS TO INCREASE SPRING LAMB PRODUCTION AND TO CONTROL PARASITES. J. M. Lewis, M. E. Mansfield and F. C. Hinds, *University of Illinois, Dixon Springs Experiment Station.*

Some of the problems studied were: (1) the effect of age and weight on time of weaning, (2) effect of early weaning on twins versus single lambs, (3) comparison of drylot and pasture feeding, (4) economy of gain, and (5) effectiveness of systems of management on control of internal parasites. Nine lots of grade lambs were used and lotted as follows: Lot 1—weaned and self-fed in drylot, Lot 2—lambs self-fed in drylot, ewes on pasture during the night and returned to the lambs during day, Lot 3—lambs weaned and self-fed on legume-grass pasture, Lot 4—ewes and lambs on grass legume pasture, lambs creep fed, and Lot 5—ewes and lambs on grass legume pasture, no creep. Equal numbers of single and twin lambs were used in each lot. Lots 2 through 5 were duplicated on orchard grass pastures. Our data indicate that parasites can be controlled very effectively (as measured by fecal egg counts) when lambs are not pastured with the ewes. Twin lambs performed equally as well as singles in the early weaned lots. Lambs were weaned from 45 days to 92 days of age and the younger lambs performed as well as, or better than, the older lambs. Live market grades for weaned lambs were as good as those for lambs remaining with the ewes. Early weaning did not increase death loss.

243. FURTHER STUDIES ON THE USE OF THE NUTRITIVE VALUE INDEX IN FORAGE EVALUATION. L. E. Lloyd, E. Donefer and E. W. Crampton, *Macdonald College (McGill University), Canada.*

Samples of alfalfa and bromegrass hays, harvested at the early-, full- and post-bloom stages of maturity, were chopped into lengths of 1–2 inches and artificially cured. Each forage at each maturity stage was fed to lambs in the chopped, ground and pelleted forms in an incomplete Latin Square design experiment. The determination of the relative intake and energy digestibility of each forage fed to each sheep provided for the calculation of average Nutritive Value Indices (N.V.I.'s) as originally described (J. Animal Sci. 19:538, 1960). The N.V.I. of alfalfa hay was found to be higher than that of brome grass hay regardless of stage of maturity or physical form. This was due in greater part to higher relative intake values than to a superior digestibility of energy. The N.V.I. of each forage species tended to decrease with advancing maturity, although the differences between the full- and post-bloom stages were negligible when

the forage was fed in the chopped condition. The decrease in N.V.I. with advancing maturity was greater for the grass than the legume, regardless of physical form. The advantage of grinding, as exemplified by higher N.V.I.'s, was greater for bromegrass than for alfalfa hay. A further increase in N.V.I. of all forage samples was observed when the ground material was pelleted. A progressive decrease in energy digestibility was noted in chopped *vs.* ground *vs.* pelleted forages, but this was more than compensated for by a progressively greater increase in relative intake.

244. WINTER PASTURES FOR REPLACEMENT DAIRY HEIFERS. M. E. McCullough, L. R. Sisk and O. E. Sell, *Georgia Experiment Station, Experiment.*

A three-year study of the suitability of four winter pasture types for winter replacement heifers was initiated in 1957. The four forages were: (1) ryegrass alone, (2) oats alone, (3) a mixture of oats and ryegrass and (4) a mixture of oats, ryegrass and crimson clover. The forages were seeded in September and grazing started as soon as possible. Animals used were Guernsey and Holstein heifers and steers born in August and September of the same year. Average weight of all animals at beginning of the season was 184 lb. and average weight at the season's end was 429 lb. Average length of grazing season was 142 days. Periodic measures of forage intake and digestibility were accomplished by the chromic oxide-chromogen technique. There were no significant differences between forages or years in either dry matter intake or digestibility. Average gains per acre and gains per day were: (1) 627 lb., 2.09 lb.; (2) 481 lb., 1.72 lb.; (3) 563 lb., 1.89 lb.; and (4) 790 lb., 1.91 lb. Average daily forage dry matter intake and digestibilities were: (1) 11.30 lb., 73.9%; (2) 9.47 lb., 72.8%; (3) 11.45 lb., 71.5% and (4) 11.30 lb., 74.2%. Average total dry matter consumed per acre was: (1) 3,397, (2) 2,644, (3) 3,412 and (4) 4,682 lb. At current costs, all forages except the oats alone resulted in costs less than barn feeding.

245. THE FEEDING VALUE OF CORN VERSUS SORGHUM SILAGE FOR LACTATING DAIRY COWS. R. P. Niedermeier, R. D. Lance, B. R. Baumgardt and C. R. Krueger, *University of Wisconsin, Madison.*

A double reversal feeding trial of 21-day experimental and 7-day change-over periods with 12 lactating dairy cows was conducted to compare corn silage with forage sorghum silage. Silage was fed free choice; hay was limited to approximately 6 lb. per cow daily, and grain was fed to balance the cows requirements. The corn was ensiled in the early dent stage of maturity and the sorghum in the dough stage. As fed, corn silage averaged 69.6% and sorghum silage 74.6% moisture. The protein, ether extract, fiber, ash and NFE content was 9.4, 5.9, 23.1, 5.3 and 56.4% for the corn silage and 6.8, 6.3, 23.9, 6.2 and 56.7% for the sorghum silage on a dry matter basis. The daily total and silage dry matter intakes per 100 lb. body weight were 2.88 and 1.66 lb. corn silage compared to 2.67 and 1.46 lb. for sorghum silage. Cows eating corn silage produced 41.2 lb. of FCM daily as compared to 38.1 lb. for cows fed sorghum silage. A chromic oxide indicator digestion trial was conducted in which the silage formed the entire ration for lactating dairy cows. The digestibility of the dry matter was 59.1% and 59.6% for the corn and sorghum silages, respectively.

246. ENVIRONMENTAL AND GENETIC INFLUENCE ON WINTER GAINS OF BEEF CALVES. F. M. Peacock, W. G. Kirk, J. E. McCaleb and E. M. Hodges, *Range Cattle Experiment Station, Ona, Florida.*

A total of 496 weanling calves of mixed Brahman and Shorthorn breeding was fed in three wintering trials averaging 137 days to test the nutritive value of pangolagrass utilized as silage and reserved pasture. Lot 1 was on pasture; Lot 2, self-fed silage by means of a moveable stanchion in a horizontal bunker silo; Lot 3, full-fed silage in bunks; Lot 4, self-fed silage as Lot 2 plus limited pasture. All calves were

fed the same amount of a comparable ration of 1 part 41% cottonseed meal and 2 parts citrus pulp plus 2% complete mineral, except the first year when the pasture-fed calves received less feed than calves having access to silage. Daily gain data were analyzed for year, sex, breeding of calves, sources of roughage and methods of feeding silage. There were no significant differences in gains between breeds at the generally accepted level; however, a P=.10 existed in favor of the ½ Brahman calves. The ½ Brahman calves gained 0.17 lb. daily more than the calves with ⅛ or no Brahman and 0.08 lb. more than ⅞ and purebred Brahman calves. There was no significant difference between sexes, but the adjusted means favored the male calves by 0.06 lb. daily gain. There were highly significant differences (P=.01) between silage and pasture-fed calves. Adjusted means for average daily gains for the forage groups were 0.78, 0.47, 0.53 and 0.70 lb. for the pasture, silage from silo through stanchions, silage from feed bunks and silage plus limited pasture, respectively.

247. THE EFFECT OF NITRATE IN NITROGEN-FERTILIZED HAYS ON FERMENTATION *IN VITRO*. C. B. Perez, Jr. and C. D. Story, *Colorado State University, Fort Collins.*

Mountain meadow hays produced in experimental plots fertilized with different levels of nitrogen were found to contain nitrates. These hays were evaluated in artificial rumen studies, gas production being used as a measure of their bacterial fermentation. The percentages of total gas produced from fermentation of the hays fertilized with 0, 200, 400 and 800 lb. nitrogen per acre were 100, 63, 57, and 40, respectively. These hays contained the following percentages of nitrate: alfalfa—0.29, 1.62 and 1.78 for the 0-, 400-, and 800-lb. nitrogen treatments, respectively; bromegrass—0.07, 0.81 and 2.10 for the same levels, respectively; and orchard grass—0.11, 1.46, 3.06 and 3.20 for the 0-, 200-, 400-, and 800-lb. treatments, respectively. When the corresponding amount of nitrate present in a given fertilized hay was added to non-fertilized hay in the form of nitrate salts (KNO_3, $NaNO_3$, NH_4NO_3 and $Ca(NO_3)_2$), gas production was depressed to the level noted in fertilized hay. As a check for possible depressing effect of salt concentration upon the addition of nitrate salts, other salts such as KCL $(NH_4)_2SO_4$, etc., were similarly added individually in approximately the same molar concentration. These salts depressed gas production of the non-fertilized hay by about 5%. Previous work at this station has indicated significantly lower gains of calves fed nitrogen-fertilized (90 lb. available nitrogen per acre) hay compared to calves fed non-fertilized hay. The percent of nitrate in these hays was 0.43 and 0.04, respectively. Such a level of nitrate may account in part for the significantly lower gains in these calves.

248. PECTIC SUBSTANCES IN FORAGES AND THEIR METABOLISM BY RUMEN MICROORGANISMS. R. Pressey, S. H. Synhorst, R. S. Allen and N. L. Jacobson, *Iowa State University, Ames.*

The pectic substances in birdsfoot trefoil, Ladino clover, red clover, bromegrass and five varieties of alfalfa were studied over a period of 7 weeks prior to first cutting. Samples (4-inch tops) obtained at weekly intervals were analyzed for water-soluble and total pectin and for residual uronic acids. Total pectin, on a dry matter basis, varied from 1.5% in bromegrass to 9.0% in Ladino clover. Variations in pectin content were observed within each forage, but no uniform time trends were observed. In alfalfa, the water-soluble pectin varied from 1.8 to 3.0%, while the total pectin varied from 4.8 to 6.6%. Only about 2.0% of residual uronic acids were found in all the plants studied and were reasonably constant. Pectin content was higher in samples taken at night than in those taken during the day. *In vivo* studies, employing two steers with rumen fistulas, showed that the water-soluble pectin of alfalfa consumed during grazing disappeared very rapidly from rumen contents, while the remaining pectin was utilized slowly. These observations were supported by results of *in vitro*

incubation of finely chopped alfalfa with rumen liquor, wherein water-soluble pectin disappeared within 30 minutes. Also, pectin was metabolized eight times more rapidly than its hydrolysis product galacturonic acid when incubated with rumen liquor. The rate of utilization of pectin and of galacturonic acid varied among animals and within animals from day to day. The highest activity occurred prior to feeding and lowest immediately after feeding.

249. THE RESPONSE TO STILBESTROL ON PASTURE FED ZEBU STEERS. L. R. Quinn, G. O. Mott and W. B. Bischoff, *Ibec Research Institute, Sao Paulo, Brazil.*

The influence of stilbestrol upon the performance of Zebu steers in tropical Brazil has been studied during a three-year period. Yearlings, 2-year-old and 3-year-old steers gave increases in liveweight gain of 12.6, 21.9 and 25.3 kg./head during a 140-day summer grazing season from a 24 mg. implantation of stilbestrol. Calves implanted with 12 mg. of stilbestrol at 2 to 4 wks. of age gained an additional 8.5 kg./head during the following 160-day period. Two-year-old steers, implanted with 24 mg. of stilbestrol showed an increase in liveweight gain per head of 6.1 kg. when grazed on a poor quality pasture and an increase of 18.2 kg. per head when grazed on a high quality pasture of *Panicum maximum*. Pastures during the winter dry season are low in nutritive value, giving increases for stilbestrol of 19.9 kg./head in comparison with 30.3 kg./head increase during the summer wet season on pastures of high nutritive value. Under the conditions of these trials a 24-mg. implant of stilbestrol was effective over an 8 to 9 month's period after which the response was nil. A second implant of 24 mg. at the end of the first 6 months continued to give large responses at the end of 12 months.

250. RELATIONSHIP OF FORAGE DIGESTIBILITY AND INTAKE DATA TO *IN VITRO* AND *IN VIVO* FERMENTATION INDICES. R. L. Reid, Burr Clark, J. A. Welch, G. A. Jung and D. C. Shelton, *West Virginia University, Morgantown.*

In vitro evaluation of 124 forages (from seven individual stations), for which digestibility data had been obtained with cattle and sheep, gave highly significant correlations between *in vitro* digestible cellulose at 36 hours and *in vivo* digestible dry matter or energy. Regression analysis indicated that the relationship between *in vivo* and *in vitro* determinations was the same for all stations when a grass hay inoculum was used. This was not the case with an alfalfa hay inoculum. Further trials were carried out to determine whether voluntary intake could be predicted from *in vitro* fermentation indices. Eight hays were fed (*ad libitum* consumption) to mature wethers and voluntary intake and digestibility were determined. *In vitro* cellulose digestibility was calculated at intervals of 4, 8, 12, 20, 32 and 48 hours. Cellulose digestion between 24 and 48 hours was highly correlated with *in vivo* dry matter digestibility. No consistent relationship between voluntary intake and rate of cellulose fermentation could be observed. Similar rate studies were performed by incubating forage samples enclosed in Dacron bags in the rumen of a fistulated, hay-fed sheep. Dry matter loss was determined at 4, 8, 12, 20, 32, 48 and 72 hours. The form of the rate curves was similar to that contained *in vitro*. Dry matter loss at 72 hours was highly correlated with dry matter digestion *in vivo*. Rate of loss during early fermentation could not, however, be related to *ad libitum* consumption.

251. RELATION OF CERTAIN END PRODUCTS OF RUMEN FERMENTATION TO FORAGE FEEDING VALUE. R. W. Rice, R. W. Luecke, J. A. Hoefer and R. L. Salsbury, *Michigan State University, East Lansing.*

Oat straw and alfalfa-bromegrass hay were compared by conventional total digestible nutrient determinations and by *in vitro* volatile fatty acid production and cellulose

disappearance. Alfalfa-bromegrass hay was found to have an average of only 2.4% more TDN than oat straw. Four Holstein cows voluntarily consumed an average of 23 lb. of alfalfa-bromegrass hay per head daily. A similar group of four Holstein cows voluntarily consumed an average of only 14 lb. of oat straw per head daily. On *in vitro* fermentation, alfalfa hay produced volatile acids at a significantly ($P<.05$) faster rate than oat straw. The acetic to propionic acid ratio was significantly ($P<.05$) lower for alfalfa-bromegrass hay for the first 4 hours, but not significantly different for the balance of a 24-hour *in vitro* fermentation. There was no significant difference in the percent of cellulose which disappeared in a 24-hour *in vitro* fermentation of alfalfa-bromegrass hay and oat straw. *In vitro* differences in ratio and amounts of volatile fatty acids produced were significant only when inocula were obtained from steers fed the same forage as that being used for *in vitro* substrate.

252. PALATABILITY STUDIES OF RATIONS FOR SUCKLING LAMBS. C. V. Ross and Melvin R. Karr, *University of Missouri, Columbia.*

Further studies of the importance of palatability of sheep rations for suckling lambs were made in two experiments involving 90 lambs. Shelled corn was compared with a pelleted creep ration which had previously been found unusually palatable to lambs. The pelleted ration composed of ground shelled corn 60%, soybean oil meal 30%, and wheat bran 10% was consumed by lambs more readily (2.28:1) and they gained 20% faster. Differences were significant for twins ($P<.01$) and for singles ($P<.025$). They were fatter and graded higher alive than those fed shelled corn. In a palatability test, lambs were given free access to five pelleted rations and shelled corn. The most acceptable ration of those compared was composed of 60% ground shelled corn, 30% soybean oil meal and 10% dehydrated alfalfa meal. This ration was consumed in a quantity 10.25 times greater than shelled corn. A similar ration modified by replacing 5% of the corn with corn syrup was consumed next most readily and had a rating of 9.6; and the corn 60%, soybean oil meal 30%, and bran 10% mixture had a rating of 8.4. Grinding and pelleting shelled corn apparently improved acceptability since corn so treated had a rating of 5.1.

253. PHENOTHIAZINE VERSUS METHYLPHOSPHORAMIDATE AS AN ANTHELMINTIC FOR LAMBS. C. V. Ross and Melvin R. Karr, *University of Missouri, Columbia.*

Three experiments were conducted to compare 4-tert-butyl-2-chlorophenyl methyl methylphosphoramidate (Ruelene) with phenothiazine as an anthelmintic for grazing and fattening lambs. Forty-eight lambs which had become heavily parasitized on lespedeza pasture were divided into duplicate sets of two uniform lots and drenched with the two anthelmintics. Lots I and III received 1 1/3 oz. of 40% phenothiazine and Lots II and IV received 100 mg. of the phosphoramidate per kg. of body weight. Fecal worm egg counts were made before lambs were treated and at 8 and 22 days. In addition to less thrifty appearance, lambs treated with phenothiazine had three times as many worm eggs in their feces and failed to gain as well as those which received the phosphoramidate, although differences were not statistically significant. In a second similar experiment, 54 lambs were divided into two uniform lots to compare phenothiazine with phosphoramidate given at the rate of 150 mg. per kg. body weight. The treatments were repeated in 28 days. At the end of 8 weeks lambs on the phosphoramidate had gained significantly faster ($P=.01$) and had significantly fewer worm eggs per gram feces ($P=.01$) than those treated with phenothiazine. In a third trial phenothiazine was compared to phosphoramidate at levels of 100, 150, and 200 mg. per kg. body weight. Lambs treated initially and at 28 days. Lambs drenched with phosphoramidate appeared healthier, fleshier, had somewhat lower worm egg counts, and made somewhat greater gains than those on phenothiazine, but none of the differences were statistically significant.

254. PRODUCTION OF HEREFORD COWS INDIVIDUALLY FED ON WINTER RANGE SUPPLEMENTS VARYING IN PERCENT PROTEIN AND PHOSPHORUS. O. O. Thomas, G. M. Van Dyne and F. S. Willson, *Montana State College, Bozeman.*

A three-year winter grazing and supplemental feeding study was conducted with 56 Hereford cows divided on basis of age and breeding into eight groups; replacement heifers were added to provide 10 cows per group. All cows were grazed together on winter foothill range from about December 15 to March 15 each year, and every other day they were rounded-up, run through a portable chute, and individually fed 2 lb. of a supplement containing 20, 30, or 40% protein with 0.75 or 1.5% phosphorus. A control group was given no supplemental feed. All groups were fed grass hay if snow cover was deep, and they were fed in a corral prior to and during calving. Individual feeding of supplements continued until cows were turned to grass. All cows were grazed together during the summer. No mineral supplementation except salt was provided during the trial. Level of protein and addition of P (phosphorus) in winter supplement, winter weight gain of cows (lb.), and adjusted weaning weights of calves (lb.) for the first year were as follows: Control, —19, 379; Control plus P, —44, 395; 20%, 9, 385; 20% plus P, 3, 391; 30% —8, 363; 30% plus P, —6, 401; 40%, 38, 366; 40% plus P, 11, 387. Second year results were as follows: Control, —71, 377; Control plus P, —66, 372; 20%, —20, 374; 20% plus, P, —58, 429; 30%, —19, 370; 30% plus P, 3, 391; 40%, —10, 388; 40% plus P, —15, 397. Blood analyses reflected phosphorus intake of cows. Evaluation of forage intake was conducted.

255.

256. PERFORMANCE OF ANNUAL CROPS AS PASTURE FOR EARLY WEANED LAMBS. W. F. Wedin and R. M. Jordan, *Agricultural Research Service, U.S. Department of Agriculture and Minnesota Agricultural Experiment Station, St. Paul.*

Performance of early-weaned lambs grazing five replicates of annual pastures was studied over a 2-year period. Crops tested were (1) oats-rape, all summer grazing; (2) peas, early summer grazing followed by solid-seeded corn; (3) oats-peas, early summer grazing followed by sudangrass. Tester lambs remained on trial throughout the experiment and grazer lambs were used to adjust stocking rates. Stocking rates varied from 12 to 36 per acre. Lambs pasturing a combination of oats-peas gained appreciably faster than lambs pasturing peas. On a seasonal basis, species of crop grazed had little effect on the average daily gain during the entire grazing season (oats-rape, 0.38 lb.; peas followed by corn, 0.36 lb.; and oats-peas followed by sudangrass, 0.36 lb.). Average total gain in pounds of lamb per acre for the three combinations of crops tested were: oats-rape, 313; peas-corn, 286; oats-peas, sudangrass, 291. Oats-rape provided very suitable summer pastures; oats for early grazing while the less palatable rape became established for later repeated grazings. Sudangrass recovered well for grazing from mid to late summer but oats-peas, peas and corn were only satisfactory for short periods. Annual crops should not be relied upon to provide the major amount of forage in a pasture program.

257. EFFECTS OF ANTIBIOTICS, UREA AND OTHER ADDITIVES ON PEARL MILLET SILAGE. C. J. Wilcox, J. M. Wing, R. B. Becker, J. T. McCall and G. K. Davis, *Florida Agricultural Experiment Station, University of Florida, Gainesville.*

Ten silos of polyvinyl treated canvas (capacity 6 tons) with a combination liner and cover of 8 mil polyethylene film were used to ensile direct-cut Gahi pearl millet. During October 1959, five silos were filled with first cutting forage averaging 10.4%

dry matter and 1.33% crude protein, two with second cutting (9.9 and 1.92%), and three with third cutting (15.7 and 1.79%). Additives included citrus pulp and ground snapped corn (150 lb./T.), zinc bacitracin, neomycin, and albamycin (5 g./T.), and urea (10 or 15 lb./T.), with citrus pulp (150 lb./T.). Proximate analyses were completed on forage and silage; pH was determined on the silage. Tests of silage juice and dry matter for antibiotics were negative. Proteolytic activity was light to moderate in all silos. Mean efficiency of ensilability of dry matter was 91% (range 82 to 99%); of crude protein 76% (47 to 100%). Average daily consumption of silage/1000 lb. body-weight was 105 lb., ranging from 66 (urea-treated) to 142 lb. (zinc bacitracin). Daily dry matter consumption averaged 15.0 lb., ranging from 10.1 (albamycin) to 21.2 lb. (ground snapped corn). Blood levels of urea and ammonia of animals consuming urea-treated silage increased significantly ($P<0.01$) but remained below critical levels. TDN and DCP were determined by digestion trials each involving five to eight animals.

258. SUBSTITUTION VALUES FOR CORN AND ALFALFA-BROME FORAGE FOR FATTENING STEERS. Walter Woods, J. M. School and Earl O. Heady, *Iowa State University, Ames.*

Six combinations of corn and brome-alfalfa forage (green-chop) were fed during the pasture season and compared for rate of gain, efficiency of gain, cost of gain and time required to produce choice steers in a three-year study involving 336 yearling steers. Following the green chop feeding period, all steers were placed on a full feed of corn. The combinations of brome-alfalfa forage and concentrate feed were as follows: all forage, 20 parts forage to 1 part of concentrate, 10 parts forage to 1 part of concentrate, 5 parts forage to 1 part of concentrate, 3 parts forage to 1 part of concentrate and 2 parts forage to 1 part of concentrate. The steers were full fed the above combinations during the summer period. The rate of gain during the pasture season increased as the ratio between forage and corn narrowed. The average daily rate of gain for the steers fed all forage, 20:1, 10:1, 5:1, 3:1 and 2:1 combinations was 1.34, 1.66, 1.97, 2.24, 2.45 and 2.66 pounds respectively. The feed per pound of gain on a dry matter basis decreased as the amount of corn fed per day increased. The feed cost per pound of gain decreased as the level of corn in the ration increased and also as the length of time on feed decreased; however, this relationship is subject to the relative price changes of corn and forage. The length of time to produce steers that graded choice varied from an average of 150 days for the 2:1 combination of forage and concentrate to 243 days for the steers fed all forage during the summer period and then placed on a full feed of corn.

259. THE EFFECT OF VARYING THE PERIOD OF TIME BETWEEN CHOPPING AND SEALING ON THE ENSILING OF UNWILTED FORAGE IN PLASTIC LABORATORY SILOS. J. M. Yoder, D. L. Hill and N. S. Lundquist, *Purdue University, Lafayette, Indiana.*

Plastic laboratory silos were used to study the effect of varying the period of time between chopping and sealing on the resulting fermentation of various unwilted forages. The loosely packed, chopped forage was held in a large barrel. No additives were used. The pH change in a 24-hour period was from 5.6 to 6.5, 5.8 to 7.1 and 5.7 to 4.9 for sudan grass, alfalfa, and corn, respectively. In separate experiments, allowing sudan grass to stand for 12 to 24 hours before sealing resulted in silages with pH values of 5.3 and 4.6 compared to 4.9 and 4.5 for the respective controls. In three experiments, alfalfa which stood for 0, 3, and 12 hours resulted in silages after 7 months with average pH values of 4.6, 5.2 and 5.6, respectively. The average titratable acidities were 1.99, 1.22, and 0.82% calculated as lactic acid. The average concentration of volatile fatty acids (acetic, propionic, and butyric) per gram of silage dry matter was equivalent to 6.50, 10.12, and 11.57 ml. of 0.1N KOH. The average lactic acid content was equivalent to 4.03, 0.50, and 0.08 ml. of 0.1N KOH.

260. EARLY PREGNANCY LOSS IN SHEEP AT AMBIENT TEMPERATURES OF 70° AND 90° F. C. W. Alliston and L. C. Ulberg, *North Carolina Agricultural Experiment Station, Raleigh.*

Previous observations (J. Animal Sci. 18:1550) were continued for a second breeding season. A total of 120 detailed observations were made on embryos or ovulations of yearling and 2-year-old ewes maintained at ambient temperatures of 70° or 90° F. with approximately 65% relative humidity. Allocation to temperature groups was made 5 days before predicted estrus where estrus in donor and recipients was synchronized to within 24 hours either spontaneously or with the aid of hormones. Donors were bred by natural service to rams producing high quality semen. Transfers were performed 60–84 hours later. Results of all observations were based on a laparotomy performed 25–30 days after transfer. Significant increases of rectal temperatures (104.1 ° F. vs. 102.3° F.) and respiration rate (136/min. vs. 64/min.) were observed in ewes at the higher temperature. Fertilization rate was significantly higher in the 70° F. group (95% vs. 52%). Thirteen of 23 transferred embryos resulted in pregnancy in "between animal" transfers where both donor and recipient were maintained at 70° F. When donor and recipient were maintained at 70° F. and 90° F., respectively, 6 of 25 transfers resulted in pregnancy. Only 2 of 21 transfers resulted in pregnancy where donor and recipient were held at 90° F. and 70° F., respectively. When embryos were transferred "within animals" 6 of 8 and 0 of 2 transfers resulted in pregnancy in 70° F. and 90° F. groups, respectively. Five "untransferred pregnancies" were diagnosed from seven CL in ewes of the 70° F. group as compared with none of four in the 90° F. group.

261. EFFECT OF CARBON DIOXIDE AND BICARBONATE CONCENTRATIONS ON SPERMATOZOAN LIVABILITY. F. D. Bartlett, Jr. and N. L. VanDemark, *University of Ilinois, Urbana.*

Highly successful fertility results have been obtained with bull sperm stored in CO_2 saturated diluents (Illinois, Arkansas, Tennessee, France, and Germany). The importance of maintaining high CO_2 concentrations is indicated by the increased survival obtained when semen is sealed in ampules in which the liquid phase is larger than the gas space, thus insuring that the dissolved CO_2 remains at high levels. The effect of HCO_3^- concentrations on CO_2 solubility is an important consideration for optimal sperm survival. Using a diluent which generated its own CO_2, by the action of citric acid and $NaHCO_3$ it was possible to determine the amount of CO_2 generated and to establish the optimum CO_2 and HCO_3^- relationship. A mixture producing 0.105 molar concentration of CO_2 and a 0.025 molar concentration of HCO_3^- resulted in better sperm survival over a 20-day storage period at 5° C. than a diluent containing the same concentration of HCO_3^- and saturated with CO_2. Other diluents containing higher concentrations of HCO_3^- and lower concentrations of CO_2 were less effective. The saturation of a mixture of salts and organic materials containing an 0.025M concentration of $NaHCO_3$ with CO_2 resulted in poorer sperm survival than when the $NaHCO_3$ concentration was increased to 0.05M or 0.10M. Flushing the ampules with 100% CO_2 prior to filling increased the percentage of motile sperm 2 to 5%. At the 0.10M level of $NaHCO_3$ with flushing, the percentage of motile sperm decreased from 71% to 69% in 7 days and to 60% and 47% in 20 and 60 days, respectively. Even after 90 days of storage, 18% actively motile sperm were observed.

262. OBSERVATIONS ON THE OCCURRENCE OF ARBORIZATION IN THE CERVICAL MUCUS OF THE SOW. K. J. Betteridge and J. I. Raeside, *Ontario Veterinary College, Canada.*

Dried smears of cervical mucus collected from sows and gilts at all stages of the estrous cycle have been examined for arborization. Preliminary investigations on nine

animals indicated that the phenomenon occurred for a restricted period of the estrous cycle, principally during pro-estrus. These observations have been confirmed over 11 heat periods in a more intensive study of the estrous cycles of five sows. Arborization was found for 1 to 7 days (mean 3.3 days) with most patterns appearing 2 days before the first day of estrus. During these cycles, an association between estrus and an increase of reducing substances in cervical mucus was suggested by the use of one proprietary indicator. Samples of cervical mucus from 19 sows at varying stages of pregnancy were examined. Special emphasis was placed on the 3rd to 7th weeks of gestation, during which time seven animals were examined almost daily. Between days 13 and 60 of gestation, a total of 216 samples from 10 females (mean of 4.5 females per day) were all negative for arborization. From day 61 to day 90, 103 samples from 11 females (mean of 3.4 per day) included two showing arborization and six with weak pattern formation. These eight samples were from five different animals. From day 91 until term, 110 samples from eight females (mean 4.4 per day) included a single positive smear from each of two animals.

263. REPRODUCTIVE PERFORMANCE OF MILKING SHORTHORN HEIFERS AS AFFECTED BY CONSTANT HIGH ENVIRONMENTAL TEMPERATURE. J. Bond, R. E. McDowell, W. A. Curry and E. J. Warwick, *U. S. Department of Agriculture, Beltsville, Maryland.*

Twelve two-year-old heifers were paired by weight and placed on experiment December 16, 1959. Six were kept in a psychrometric chamber of 29 weeks at 90° F. and 60% relative humidity. Their pair-mates were kept under usual housing conditions. Simulated photoperiod in the chamber corresponded to daily variation characteristic of the season. The heifers were pair-fed a constant amount (above maintenance) of a high energy-low fiber, pelleted ration. The heifers were checked for estrus twice daily and ovarian activity was determined by weekly rectal palpation. Five treated heifers ceased to cycle after 5 weeks (average) on experiment. This period coincided with peak rectal temperatures and respiration rates. Ovaries of the non-cycling heifers remained active to the extent of follicle formation without maturation and ovulation. At about 7 weeks the treated heifers shed their long winter hair coats. This was followed by a decrease in rectal temperatures and respiration rates until at approximately 17 weeks nearly normal levels were reached. By the 21st week the treated heifers had re-established their estrous cycles, and after this all heifers (treated and control) were bred. Five treated and six control heifers conceived with average services per conception of 1.2 and 1.5, respectively. Pregnancy was maintained in the treated heifers for 66 days (average) under experimental conditions.

264. EFFECT OF ENVIRONMENTAL TEMPERATURE ON THYROID SECRETION OF RAMS. Jerry R. Brooks, C. V. Ross and Gayle Pipes, *University of Missouri, Columbia.*

Sixteen purebred Hampshire rams were used in trials in which 49 secretion rates were determined over a temperature range of 46°–87° F. The experimental techniques employed were a modification of that reported by Pipes *et al.* (*J. Dairy Sci.* 40:340, 1957). Thyroid secretion rate decreased with increasing temperature. When secretion rate (Y) was plotted as a regression with increasing temperature (X) the slope of the line best describing the regression was $Y=.653+(-.0039)X$. The correlation coefficient, 0.363, was highly significant ($P<.01$). The range of thyroid secretion rates was 0.2 to 0.7 mg. L-thyroxine per 100 lb. body weight. Overall, the average temperature and thyroid secretion rate was 68° F. and 0.39 mg. L-thyroxine, respectively, with a standard deviation of 0.138 mg.

265. *PRE-PARTUM* IMMUNIZATION OF SOWS TO SEVERAL BACTERIA ON GROWTH RATE AND SURVIVAL OF BABY PIGS. Herbert Brown, *Illinois State Normal University, Normal.*

Thirty-five sows of mixed breeds were used to study the effects of *Pre-partum* immunization to a mixed bacterin of the following composition: *Salmonella cholerasuis* 15%, *Salmonella schotlmulleri* 15%, *Pasteurella suiseptica* 10%, *Escherichia coli* 15%, *Streptococcus agalactiae* 20%, *Streptococcus* (pyogenic) 5%, and *Staphylococcus aureus* 20%. Sixteen sows received 10 ml. of the mixed bacterin 6 weeks and 3 weeks *pre-partum*. Nineteen sows were used as saline controls. The average number of live pigs per litter at birth, 3 weeks, 5 weeks, and 8 weeks was 8.84, 7.95, 7.16, respectively, for the control sows, and 9.12, 8.25, 8.00, 7.75, respectively, for the immunized sows. The percentage of pigs surviving to 3 weeks, 5 weeks, and 8 weeks was 89.90, 83.33, 80.95, respectively, for the control sows, and 90.40, 87.67, 84.93, respectively, for the immunized sows.

266. A TECHNIQUE FOR THE PREPARATION OF WHOLE ORGANS. E. V. Caruolo and W. A. Olson, *University of Minnesota, St. Paul.*

A technique has been employed whereby certain whole animal organs are permanently prepared in dry rigid form maintaining life-like characteristics. This method has been used in the preparation of material such as uteri and ruminant stomachs to be used for demonstrational and instructional purposes. The organ to be prepared is first washed or flushed to free it from foreign matter. Excess tissue and fat are removed. The preparation is emersed in methyl alcohol for a period of time sufficient to permit complete permeation, usually 5 days. The organ is dried by forcing through it dry, room-temperature air at a pressure sufficient to insure maintenance of the desired size and shape. When completely dry, successive layers of polyester resin are applied. The specimen may be partially dissected subsequent to application of the first few layers of resin, allowing disclosure of internal structure. Organs prepared one year ago have not shown signs of deterioration.

267. INFLUENCE OF SOME ADRENAL AND GONADAL HORMONES ON WEIGHT GAINS IN WEANED LAMBS. M. T. Clegg and G. M. Spurlock, *University of California, Davis.*

Thirty Merino wether lambs weighing about 75 lb. and 33 ewe lambs weighing about 65 lb. were randomly divided into seven groups for treatment twice weekly as follows: Group 1, 8 wethers, 5 gm. of perthane (2,2-bis[para-ethylphenyl]-1,1-dichloroethane) intrarumenally; Group 2, 8 wethers, 100 mg. of testosterone propionate (T.P.); Group 3, 7 wethers, 100 mg. aqueous suspension of cortisone acetate; Group 4, 7 wethers, 3.0 ml. vegetable oil; Group 5, 10 ovariectomized ewes, 100 mg. T.P.; Group 6, 12 ovariectomized ewes, 3.0 ml. vegetable oil; Group 7, 11 intact ewes, 3.0 ml. vegetable oil. Except as noted, materials were dissolved in vegetable oil for intramuscular injection. Animals were allowed to eat alfalfa hay *ad libitum* and sacrificed at the end of about 180 days after start of trial. Mean total gain in lb. was 26.9, 32.5, 28.6, 30.5, 36.2, 26.2, 22.7; mean specific gravity of the leg was 1.066, 1.078, 1.045, 1.066, 1.078, 1.061, 1.061; mean score of carcass grade was 67, 47, 90, 66, 51, 68, 70, in order of group number. T.P. caused a significant increase in gain and specific gravity and a reduction in carcass grade. Cortisone acetate, while not affecting gain caused a significant reduction in specific gravity and an increase in carcass score. Ovariectomy significantly increased gain over intact ewes. Other treatments did not significantly alter these parameters. Perthane brought about a significant increase in adrenal weight whereas cortisone acetate caused a significant reduction. Weights of pituitary or thyroid were not affected by any treatment.

268. EFFECTS OF ADRENALECTOMY IN THE BULL. Perry T. Cupps, M. E. Fowler, R. M. Turk and J. R. Briggs, *University of California, Davis.*

Bilateral adrenalectomies were performed on two bull calves and two sexually mature bulls. Following adrenalectomy the animals were maintained with hydrocortisone (courtesy of Merck Sharp & Dohme) and deoxycorticosterone. Withdrawal of either hormone caused deficiency symptoms within 10 to 14 days. Levels of blood glucose, potassium and sodium did not change until the terminal stages of the deficiency. At proper levels of therapy body growth was normal in the calves but the animals lost weight when the hormones were withdrawn. Horn growth was depressed in one of the young animals following adrenalectomy and they have not grown normally during therapy with the above hormones. The semen collected from one of the sexually mature bulls before adrenalectomy was low in motility and fructose, and contained between 30 and 40% of abnormal spermatozoa. The semen collected following adrenalectomy showed an increase in concentration of fructose, an increased motility and a decrease in abnormal spermatozoa. These preliminary data indicate that other steroids produced by the adrenal may be important physiologically.

269. CRYSTALLIZATION PATTERNS OF THE CERVICOVAGINAL MUCUS OF SHEEP. D. L. Daniel, D. S. Bell and V. L. Sanger, *Ohio Agricultural Experiment Station, Wooster.*

A study was conducted to determine if definite variations of crystallization pattern types, manifested by cervicovaginal mucus of Columbia ewes, were associated with the anestrous and estrous period or with stimulation from estrogenically active pastures. The various crystallization pattern types appeared after mucus from the surface of the cervix had been spread on a slide and left to dry for a period of about 4 hours. Four distinctive pattern types, classified as amorphous, rosette, arbor, and fern, were observed. Anestrum was characterized by the arbor and the rosette patterns which tended to appear in a 17-day cyclic manner interspaced by the amorphous pattern type. Estrus was characterized by the rosette, the arbor, and the fern patterns; and the fern pattern seemed to be associated only with the estrus period. Metestrum and diestrum were normally characterized by the amorphous pattern type. No observations were made during pregnancy. No association was found between the estrogenic (Ladino clover) and nonestrogenic (bluegrass) pastures (1959 pasture season) and the pattern types. On the basis of single observations, it appears that crystallization pattern types may supply an indication of "silent heat" and embryonic death. Evidence was obtained that the technique used by the operator could bring about transition, disintegration and inhibition of the crystallization pattern types.

270. ORAL 9-FLUOROPREDNISOLONE ACETATE THERAPY IN THE TREATMENT OF BOVINE KETOSIS. J. L. Davidson, R. A. Gessert, A. W. Neff and N. D. Connor, *Veterinary Division, The Upjohn Company, Kalamazoo, Michigan.*

Oral administration of 40 to 60 mg. 9-fluoroprednisolone acetate to non-ketotic cows elicited the same magnitude of blood glucose response as that obtained with intramuscular administration of 10 mg. of the corticosteroid. Similar effects were elicited in ketotic cows when the drug was administered *per os*. Single oral doses demonstrated efficacy in the treatment of bovine ketosis. Repeated oral administration produced more sustained blood glucose levels. Oral administration also appears useful in sustaining blood glucose levels following intramuscular corticosteroid therapy.

271. INFLUENCE OF ORALLY ADMINISTERED PROGESTINS ON ESTRUS AND OVULATION IN SWINE. P. J. Dziuk, *University of Illinois, Urbana.*

Control of estrus and ovulation in swine could provide a useful tool in swine management. Experimental animals consisted of 117 treated females (10 sows, 107 gilts)

divided into 12 groups and control females. Treatment consisted of incorporating either crystalline progesterone or 6α methyl 17α hydroxyprogesterone acetate (Provera, The Upjohn Co.) into the diet, then feeding from 4 to 12 lb. of this diet per day per animal for 14 to 21 days. Treatment was started either immediately after weaning their litter or to normally cycling gilts without regard to the stage of the cycle. The animals ingested 1000 mg. of progesterone daily or from 20 to 300 mg. of Provera daily. Estrus was inhibited in five of 8 gilts receiving 1000 mg. progesterone per day but ovulation was not inhibited. Estrus was inhibited by all levels of Provera but ovulation was inhibited only by levels exceeding 50 mg. per day per gilt. On the 4th, 5th, 6th or 7th day after resuming normal diet 50% of the animals showed estrus and 80% ovulated. Conception rate and numbers of fetuses (litter size) were not different from similar groups not treated. Several factors influenced effectiveness of treatment.

272.

273. MUSCULAR DYSTROPHY AS INFLUENCED BY SULFUR AMINO ACIDS, SELENIUM, AND ANTIOXIDANT IN LAMBS FED COCONUT OIL-TORULA YEAST DIETS. E. S. Erwin, W. Sterner, R. S. Gordon, L. J. Machlin and L. Tureen, *Monsanto Chemical Company and St. Louis University Medical School.*

Day-old lambs were fed for 60 days on synthetic milk diets which contained 24.8% coconut oil and in which Torula yeast served as the only source of protein. The lambs were subjected to a 2^3 factorial type study that involved sulfur amino acid (0.6% methionine hydroxy analogue), antioxidant (0.1% Santoquin), and selenium (1.4 ppm.) as Na_2SeO_3. The presence of the sulfur amino acid did not affect the incidence of muscular dystrophy. Based upon clinical and gross pathological examination the addition of Santoquin to the diets completely prevented the dyscrasia. Lambs fed no Santoquin and selenium produced profound clinical symptoms of muscular dystrophy between 24 and 50 days of age. The addition of selenium to the diets modified the severity and clinical incidence of dystrophy, and only 3 of the 12 lambs fed selenium without antioxidants exhibited clinical symptoms. The syndrome was not as severe, and the lambs appeared to recover. Gross pathological examination revealed that at least 9 of the 12 were dystrophic. Blood was analyzed weekly for transaminase. In all lambs fed no antioxidant SGOT values ranged from 600 to 2000 units between 24 to 40 days of age compared to 80 to 140 units for the others. Other abnormalties such as hydropericardium, liver degeneration, brownish fat, and petechial hemorrhage of kidneys were observed in lambs fed no antioxidants.

274. EFFECT OF BODY AND SCROTAL TEMPERATURE ON METABOLIC ACTIVITY OF RABBIT TESTIS IN VITRO. L. L. Ewing and N. L. VanDemark, *University of Illinois, Urbana.*

The degeneration of the germinal epithelium of the testis as a result of temperatures higher than those in the scrotum has long been known. The cause of this degeneration has not been clearly defined. In studies with the perfused testis of the rabbit it was found that metabolism was altered by the temperature at which the perfusion was carried out. Following this lead, studies have been made of the metabolism of slices of rabbit testis after 24 hours in the abdominal cavity compared to slices of the other testis that remained in the scrotum. Oxygen uptake under two levels of oxygen tension and CO_2 production under anaerobic conditions were measured in the Warburg apparatus at 37° C. Chemical analyses were made for glucose utilization and lactic acid production. It was observed that the tissue which had been subjected to the abdominal temperature showed less endogenous metabolic activity as indicated by 26% lower O_2

uptake, 34% lower CO_2 production, and 56% lower lactic acid production. In the presence of added substrate there was very little difference in the oxygen consumption and CO_2 production of the two tissues. However, aerobically glucose uptake was about 20% lower and lactic acid production about 40% reduced in the tissues subjected to abdominal temperatures.

275. FERTILITY OF ARTIFICIALLY INSEMINATED ESTROUS CONTROLLED GILTS. N. L. First, J. A. Hoefer and J. E. Nellor, *Michigan State University, East Lansing.*

Sixty-eight crossbred gilts were orally fed 6-methyl-17-acetoxy progesterone for 15 days. Sixty-six gilts exhibited standing estrus and 94% began estrus during the 43-hour period of 77 to 120 hours after the last hormone feeding. All were artificially inseminated at the controlled estrus. Twenty-five were pregnant on slaughter at 25 days gestation. The correlation between gilt weight and conception was 0.29. Thirty-one percent of 32 gilts inseminated on the 4th day and 44% of 32 gilts inseminated on the 4th and 5th day after hormone withdrawal, conceived. Fourteen of 32 gilts inseminated with individual boar ejaculates and 10 of 32 gilts inseminated with pooled ejaculates conceived. There was no significant difference in sperm motility or agglutination between pooled and individual ejaculates. The effects of insemination frequency and pooled ejaculates on number of fetuses produced were not significant. Fifty gilts were orally fed 6-methyl-17-acetoxy progesterone for 15 days. Thirty-eight were artificially inseminated with 35 or 70 ml. of yolk-glucose-bicarbonate diluted boar semen. Twenty-one gilts settled from first service and farrowed an average of 7 pigs all within a 7-day interval. Eight of 19 gilts inseminated with 35 ml. and 13 of 19 gilts inseminated with 70 ml. of semen conceived from first service.

276.

277. EFFECTS OF OVARIAN HORMONES ON POST-PARTUM REPRODUCTIVE ACTIVITY IN BEEF COWS. W. D. Foote, H. J. Weeth and J. E. Hunter, *University of Nevada, Reno.*

An investigation was made of the influence of certain hormone treatments on the variation in the time of estrus and ovulation and on fertility in post-partum cows. Fifty Hereford cows were divided at random at time of calving into two equal groups. One group served as untreated controls. All cows of the other group received a single subcutaneous injection of suspended progesterone 30 days after the last calving date in that group. Thirteen of these animals were given a subcutaneous injection of 10 mg. estradiol in corn oil 20 days after progesterone administration. One cow assigned to the progesterone group and four assigned to the progesterone + estrogen group came into heat before the progesterone was given. All 50 cows were bred at the first estrus after 50 days post-calving. Neither treatment affected time from calving to first service. Average days to first service for untreated, progesterone treated, and progesterone + estrogen treated cows were 76.8, 79.1 and 76.2, respectively. Although progesterone, when given alone, did not satisfactorily synchronize heat, both treatments tended to decrease the variation in time of estrus. The respective average intervals in days from progesterone treatment to ovulation and to estrus was 24.3 and 27.3 for the progesterone group and 30.2 and 22.5 for those given estrogen. Ten of the 13 cows given estrogen came into heat and were bred the day following estrogen treatment. Four of these did not ovulate and none conceived at this service. Their following estrual cycles and fertility tended to be normal. Cows given progesterone only did not differ from untreated cows in conception rate at first service.

278. NITRATE LEVELS IN BOVINE AND PROCINE SERUM. G. B. Garner, C. N Cornell, J. H. Moyer, M. E. Muhrer and W. H. Pfander, *University of Missouri, Columbia.*

The level of nitrate in serum is not a reliable measure in diagnosing nitrate toxicities. However, both ruminants and mono-gastric animals do reflect the nitrate level of the ration when the total ration contains the nitrate; for example, cattle grazing sudan as sole source of feed or sows on an experimental ration containing a fixed percentage of nitrate. Normal bovine serum levels were found to be 1.06 ± 0.29 mg. percent potassium nitrate (KNO_3). A range of 0.50–1.80 mg. percent KNO_3 (64 samples from slaughter house on eight different dates) was found. The highest serum level found in non-pathological cattle eating silage (1.0% KNO_3) was about 3.0 mg. percent. Serum from a pathological cow (abortion) contained 16.0 mg. percent (1.8% KNO_3/D.M. sudan pasture). Serum from sows in dry lot contained 1.7 mg. percent KNO_3 (0.4–3.1 mg. percent). When placed on an experimental ration with 0.5, 1.0, and 2.0% KNO_3 the serum nitrate averages were 4.1, 5.8 and 11.2 mg. percent KNO_3. A more accurate evaluation of nitrate toxicity cases can be made from ration and water analysis than from serum nitrate levels. Nitrite levels in serum are nil, with a few exceptions, because nitrite combines with hemoglobin. The nature of the nitrate toxicity syndrome and the physiology of each animal must be considered when evaluating serum levels.

279. EFFECT OF REPRODUCTIVE STAGE ON THE ACID AND ALKALINE PHOSPHATASE ACTIVITY IN THE ENDOMETRIUM OF GILTS. L. Goode, A. C. Warnick and H. D. Wallace, *University of Florida, Gainesville.*

The alkaline and acid phosphatase activity of the uterine endometrium was determined in 20 gilts slaughtered at various reproductive stages. Para-nitrophenyl phosphate buffered at the appropriate pH ranges was used as the enzyme substrate. A unit of phosphatase activity was arbitrarily defined as the amount of enzyme liberating 1.0 μM of p-nitrophenol. Tissue enzyme activities were expressed as units of activity per milligram of fresh tissue per one-half hour. Both alkaline and acid phosphatase activities varied markedly with stage and followed an inverse relationship. The reproductive stages studied and the average units of alkaline and acid phosphatase activity, respectively, were (1) 8 days after estrus 7.0, 1.5; (2) 18–19 days after estrus 1.1, 1.8; (3) during estrus 3.4, 1.0; (4) 3 days after breeding 9.3, 1.1; (5) 8 days after breeding 6.7, 1.6; (6) 12 days after breeding 1.9, 2.6; (7) 25 days after breeding 0.5 and 5.7. Differences between reproductive stages were significant ($P<0.01$) for both alkaline and acid phosphatase activities.

280. GONADOTROPHIN ACTIVITY OF SWINE PITUITARIES AS INFLUENCED BY METHOD OF ASSAY, DOSAGE LEVEL, AND REPRODUCTIVE STAGE. L. Goode, A. C. Warnick and H. D. Wallace, *University of Florida, Gainesville.*

Composited anterior pituitary glands from slaughter weight barrows and gilts were bioassayed for gonadotrophic potency using day-old White Leghorn cockerels injected at total dosage levels of 1.0, 2.0, 3.0, 6.0 and 9.0 mg. of pituitary powder. A standard preparation of Vetrophin was assayed simultaneously at total dosage levels ranging from 0.0 to 2,000.0 I.U. in 250.0 I.U. increments. Total doses of pituitary powder and standard were administered over two injection periods, three injections 12 hr. apart (36-hr. assay) and eight injections 12 hr. apart (96-hr. assay). Degree of stimulation was determined by testes weight 12 hr. after the last injection. In both the 36-hr. and 96-hr. assay the standard preparation gave a curvilinear increase in testes weight up to the 1,000.0 I.U. dosage level. Differences between dosage levels of pituitary powder were not significant in the 36-hr. assay. In the 96-hr. assay the 1.0-mg. dose

was significantly lower ($P<0.05$) than the others. Stimulation of the seminiferous tubules at all dosage levels was confirmed by histological examination. The coefficients of variation, approximately 25.0%, were the same for both methods of assay. In another experiment composited pituitary glands from gilts slaughtered 3 and 25 days after breeding were compared in a 36-hr. assay at total dosage levels of 3.0, 6.0 and 9.0 mg. Mean testes weights for the three dosage levels were 12.4, 14.8, 13.6 and 19.1, 14.9, 14.0, respectively, for the 3- and 25-day slaughter periods. Overall differences between slaughter times and dosage levels were not significant. However, the dosage $\times$ slaughter time interaction was significant ($P<0.01$).

281. EFFECTS OF A HIGH LEVEL OF TRIIODOTHYRONINE ON SPERM OUTPUT IN RABBITS. L. C. Gray, R. H. Foote, E. E. Swierstra and R. W. Bratton, *Cornell University, Ithaca, New York.*

Eighteen Dutch-Belted rabbits were placed on experiment in April, 1959, and two ejaculates of semen were collected from each buck at weekly intervals for 27 weeks. After 9 weeks for standardization two groups of nine bucks each were formed. One group served as the control, and the other group received 10 μg. triiodothyronine (supplied by Smith Kline & French) per kg. of body weight daily for 5 weeks, a dosage considered to stimulate hyperthyroid conditions. Following treatment, semen collections were continued for 13 weeks. Because at least 7 weeks are required in the rabbit for sperm formation and transport, changes in spermatogenesis due to and following treatment would not be reflected in semen quality immediately. Therefore, the post-treatment phase was divided into a latent recovery period of 7 weeks and a final recovery period of 6 weeks. During treatment, feed consumption and body weight of the treated group dropped significantly below that of the controls, $P<0.01$, but they began to recover immediately after treatment stopped. Sperm output in millions per buck per week during the standardization, treatment, latent recovery and final recovery periods for the control and treated groups was 363 vs. 346, 307 vs. 281, 285 vs. 154, and 327 vs. 260, respectively. The difference between groups during the latent recovery period was statistically significant, $P<0.05$. The treated group began to recover by the end of this time; and, sperm production, feed intake, and body weight were normal at the termination of the experiment. The thyroids of treated animals examined histologically also were normal.

282. THYROID AND LACTOGENIC HORMONE SECRETION DURING DECLINING PHASE OF LACTATION. Clark E. Grosvenor, *University of Tennessee, Memphis.*

Since secretion of milk is known to be under hormone control, the possibility exists that the ultimate decline and cessation of lactation may be partly due to inadequate secretion of one or more of the hormones. Experiments were designed to ascertain whether decline in milk secretion of lactating rats was associated with a reduction in secretion of lactogenic hormone, which is essential for maintenance of milk secretion, and thyroid hormone which, though not essential, is known to influence the degree or extent of milk secretion. Thyroid hormone secretion rate (TSR) obtained during the declining phase of lactation was reduced 50% from average level of 1.9 μg/100g/day l-thyroxine obtained from the same animals during the period of intense milk secretion. A further decline in TSR to the vicinity of control non-lactating level (0.83 μg/100g/day) occurred shortly after cessation of lactation. Pre-nursing pituitary lactogenic hormone concentration was 70% less during declining lactation than during intense lactation. Stimulus of nursing for 30 min. evoked a discharge of 0.06 I.U./mg. pituitary during intense lactation but only 0.004 I.U./mg. pituitary during declining lactation. Pituitary lactogenic fell to the control non-lactating level shortly after cessation

of milk secretion. These data suggest that intensity of lactation is associated with intensity of thyroid and lactogenic hormone secretions and that inadequate secretion of either hormone may be an important factor in the decline in milk secretion.

283. PATTERNS OF IMPLANTATION AND EMBRYONIC SURVIVAL IN THE RABBIT AS STUDIED BY OVA TRANSFER TECHNIQUE. E. S. E. Hafez, W. L. Hunt and M. E. Ensminger, *Washington State University, Pullman.*

The effect of number of corpora lutea on survival of implantations was investigated by transferring abnormally large and small number of ova to pseudopregnant rabbits. Fertilized ova were collected *in vitro* from 68 pubertal rabbits superovulated by gonadotropins. Healthy ova (1036) were selected and a variable number of ova were transferred to both sides of the Fallopian tubes of 68 adult recipients at synchronous stage of pseudopregnancy. The recipients were laparotomized 8 days *post coitum* and the uterine swellings were counted and measured. The animals were sacrificed 15 or 29 days *post coitum* and the viability of embryos or fetuses was recorded. The number of implantations 8 days *post coitum* varied from 1 to 16. Embryonic survival at 15 days *post coitum* was 49% with 1 to 4 implants, 71% with 5 to 8 implants, 81% with 9 to 12 implants and 58% with 13 or more implants. Embryonic survival rate was lower when the number of implantation was less than 4 or more than 13. The presence of all implantations in one horn (5 to 8 implants) had no apparent effect on survival rate at 15 days *post coitum*. Fetal survival at 29 days *post coitum* was 49% with 1 to 10 implants, and 63% with 11 to 16 implants. There was no indication that high fetal mortality was associated to large number of implantations in relation to the normal quota of corpora lutea.

284. ESTRUS CYCLE REGULATION IN BEEF CATTLE BY ORALLY ACTIVE PROGESTATIONAL AGENTS. W. Hansel and P. V. Malven, *Cornell University, Ithaca, New York.*

After preliminary work with Holstein heifers indicated that orally administered medroxyprogesterone acetate prevented estrus and ovulation until 3–5 days following its withdrawal, two groups of 22 and 10 Hereford cows were fed the hormone in an attempt to produce synchronous estrus. The hormone was fed for 10 days at the rate of 968 mg./animal/day and at the rate of 500 mg./animal/day for an additional 10 days. No animals came in estrus during the 20-day feeding period. Nine of the 22 animals in the first group came in estrus on the 3rd and 4th days following the end of treatment and 7 of the 10 animals in the second group came in estrus on the third day. All animals were bred artificially regardless of whether they came in estrus and one half of them were injected with 0.5 mg. estradiol at the time of breeding. Rectal palpations indicated that 13 of the 16 animals not showing estrus ovulated. Eight of the 22 animals in the first group conceived to the first service. Five of the 9 cows showing estrus and 3 of the 13 not showing estrus conceived. The conception rate was equal in the estradiol treated and untreated groups. In a second experiment 18 cows were fed 17-ethynyl-$\Delta^{5\,(10)}$ estrenolone (containing 1.5% 3-methyl ether of ethinyl estradiol) for 20 days at a rate of 187 mg./animal/day. This treatment was not effective in inhibiting estrus since 11 of the 18 cows came in estrus during the feeding period.

285. SOME PHYSIOLOGICAL EFFECTS OF DIETHYLSTILBESTROL IMPLANTS IN SUCKLING LAMBS. E. E. Hatfield, Nelson Gay and U. S. Garrigus, *University of Illinois, Urbana.*

A random sample half of 132 spring lambs sired by Hampshire, Southdown, Suffolk, and Targhee rams and from western crossbred ewes were implanted with a 3-mg. pellet of DES when they were approximately 4 weeks old. The lambs had access to one

of two creep rations and remained with their dams for ten more weeks. After weaning the lambs were kept in drylot on the same creep ration until they reached market weight. The following data were obtained: ADG; cooler shrink of the carcasses; pounds of constant pull to remove the pelts; weight of the pelts; adrenal, anterior pituitary, and thyroid weights; and the gonad weights of the ram and ewe lambs. As compared to their controls, the ADG of the implanted ram lambs was less ($P<.05$); the pounds of constant pull to remove the pelt were more ($P<.001$) for the implanted lambs; the average adrenal weight of the implanted ewe lambs was heavier ($P<.05$); the average weight of the anterior pituitary of the implanted ram lambs was slightly but non-significantly ($P<.1$) heavier; the average thyroid weight of the implanted ram lambs was heavier ($P<.05$); the average ovary weight of the implanted ewe lambs was lighter ($P<.05$); and, the average weight of the testes of the implanted ram lambs was lighter ($P<.001$). The young suckling lambs have not responded in gain to DES in the same manner that older feeder lambs have responded in previous experiments at this station.

286. MAINTENANCE OF PREGNANCY DURING EARLY GESTATION IN OVARIECTOMIZED DAIRY CATTLE. H. W. Hawk, G. D. Turner, T. H. Brinsfield, G. E. Whitmore, M. A. Norcross and J. F. Sykes, *Animal Husbandry Research Division, ARS, Agricultural Research Center, Beltsville, Maryland.*

Six dairy animals were inseminated artificially with fresh diluted semen. Both ovaries were removed from each animal through a flank incision, 5, 6, or 7 days after heat. On the day prior to ovariectomy and daily thereafter each animal was injected subcutaneously with progesterone in olive oil at the rate of approximately 25 mg. per 100 pounds of body weight. Estrone in olive oil was injected daily at approximately 6.25 mcg. per 100 pounds of body weight. An amnionic vesicle was palpated per rectum in each animal 35 days after heat. Three animals were killed 50 days after heat and the three others at 58, 61 and 62 days. At autopsy, uteri of five animals contained live fetuses. The uterus of the 62-day cow contained a degenerated fetus and membranes. Each of the five live fetuses was of normal length and weight for its stage of development. Exogenous hormones were thus able to maintain pregnancy through the stage of placentation in ovariectomized dairy cattle.

287. VARIATION DURING THE ESTROUS CYCLE IN THE INFLAMMATORY RESPONSE AND BACTERICIDAL ACTIVITY OF THE SHEEP UTERUS. H. W. Hawk, G. D. Turner and J. F. Sykes, *Animal Husbandry Research Division, ARS, Agricultural Research Center, Beltsville, Maryland.*

Estrual and luteal-phase sheep in pairs were inoculated in one ligated uterine horn with *Escherichia coli*. Six pairs were killed 4 hours after inoculation, eight pairs were killed at 8 hours and six pairs at 12 to 24 hours. Each inoculated horn was flushed with sterile saline solution. Numbers of live *E. coli* recovered were estimated from colony counts of diluted flushings. The number of leukocytes flushed from each horn was estimated microscopically. The degree of leukocytic infiltration of uterine tissues was graded by microscopic examination of tissue sections. The leukocytic response to inoculation developed significantly faster in estrous sheep ($P<0.01$) and *E. coli* were cleared from the uterus at a faster rate ($P<0.05$). The differences between sheep of the two endocrine states were greatest at 8 hours, then decreased in magnitude as the inflammatory response developed in the luteal-phase sheep. The degrees of leukocytic infiltration of the endometrium and the mean numbers of leukocytes and live *E. coli* flushed from the uterine lumena were as follows (numbers of leukocytes and *E. coli*, respectively, in millions): 4-hour estrual sheep, moderate infiltration, 28 and 245; 4-hour luteal-phase sheep, slight, 8 and 316; 8-hour estrual sheep, very heavy, 115 and 20; 8-hour luteal-phase sheep, moderate, 25 and 282; 12 to 24-hour estrual sheep, heavy, 251 and 0.3; 12 to 24-hour luteal-phase sheep, heavy, 254 and 4.

288. EFFECT OF ENVIRONMENTAL LIGHT AND TEMPERATURE ON THE THYROID SECRETION RATE IN SHEEP. T. M. Hoersch, E. P. Reineke and H. A. Henneman, *Michigan State University, East Lansing.*

Thyroid secretion rates were obtained on 65 ewes under controlled conditions of temperature and artificial light. This investigation was carried out with 12 combinations of light and temperature, each trial lasting 30 days. Decreasing the ambient temperature from 90° F. to 50° F. induced a three-fold increase in the thyroid secretion rate, which was significant ($P<.01$). Increasing the hours of light in increments of 4 hours produced a biphasic effect within the range 4 through 24 hours per day. Differences between the highest and lowest values were significant ($P<.01$). By increasing the illumination from 4 hours daily to 12, thyroid activity was progressively depressed, but with added light above 12 hours the thyroid secretion rate steadily rose. The highest values were obtained under continuous light and the parabolic pattern was in evidence under both 50° and 90° F. temperatures. Ten individual comparisons were made between the thyroid secretion rate and thyroid epithelial cell height in ewes maintained under 12 hours of light. There was a positive relationship ($r=0.58$, $P<.08$) between these measures which approached significance. The acinar cell heights of ewes subjected to the 50° F. temperature were significantly ($P<.01$) greater than those of ewes kept at 90° F. Thyroid secretion rate could be significantly ($P<.05$) correlated ($r=+.268$) with feed efficiency and a positive correlation of 0.240 existed between secretion rate and body weight gain; this approached significance ($P<.06$).

289.

290. TEMPERATURE-HUMIDITY EFFECTS ON THYROXINE I^{131} DEGRADATION RATES OF CATTLE. H. D. Johnson, H. H. Kibler and A. C. Ragsdale, *University of Missouri, Columbia.*

The effects of higher environmental temperatures and humidities on peripheral metabolism of the hormone have not been studied though it is known that the thyroid gland in cattle is depressed at higher environmental temperatures. To investigate this problem the disappearance rates of injected thyroxine I^{131} were determined in the blood and milk of lactating Holstein cows. Thyroxine I^{131} was injected via the juglar vein and daily samples were taken for 4 days. Over a 2-year period 40 lactating cows (various stages of lactation) were exposed to various combinations of temperature and humidity above 65° F. These studies were conducted in the Missouri Climatic Laboratory utilizing a "switch-back" design. Average values for blood thyroxine I^{131} disappearance rates (K) were 16 at 65° F., 5 at 90° F., 50% R.H.; 10 at 90° F., 20% R.H.; 7 at 80° F., 80% R.H.; 9 at 80° F., 50% R.H.; 7 at 85° F., 50% R.H. A decline in the "utilization" of the hormone or decrease in peripheral degradation at temperature and humidity combinations above 65° F. is indicated by these data. Results obtained suggest that declines in milk and feed intake at higher temperatures may not be due to lack of the hormone synthesis but due to some limiting factor in the tissues.

291.

292.

293. PRELIMINARY STUDIES ON METABOLISM OF C^{14}-LABELED DIETHYLSTILBESTROL IN THE RAT. H. W. Knoche, H. C. Moser and A. M. Gawienowski, *Kansas State University, Manhattan.*

Diethylstilbestrol has been used extensively to increase the daily gain in animals used for meat; however, little is known about the metabolic pathway of this synthetic compound. Early findings have shown that high concentrations of diethylstilbestrol or

radioactive metabolites are located in the liver, kidney, and lungs. The localization study confirms previous investigators' results and gives an indication as to where the chemical conversions of diethylstilbestrol may be taking place. It was found that 0.005% of the injected dose of C^{14}-diethylstilbestrol in a rat was present in the bones of the right front leg. The leg muscle was also found to contain radioactive compounds. After an ether extract of the muscle was subjected to both column and paper chromatography, four distinct metabolites of diethylstilbestrol were indicated. The identification of these compounds is being investigated. Radioactive carbon dioxide was given off by the rat following the injection of the labeled diethylstilbestrol. The purity of the C^{14}-labeled diethystilbestrol used in these studies was checked by paper chromatography, column chromatography and infrared spectroscopy.

294. CONVERSION OF PROGESTERONE-4-C^{14} TO TESTOSTERONE-C^{14} *IN VITRO* BY NORMAL AND CYSTIC BOVINE OVARIES. S. L. Lee, G. B. Marion and A. M. Gawienowski, *Kansas State University, Manhattan.*

A disease characterized by cystic ovaries in cows and symptoms of frequent, irregular, or continuous estrum or anestrum has been known since ancient times. This investigation was based in part on the biochemical studies of the cystic bovine ovary. Our study confirms the *in vitro* conversion of progesterone to testosterone by normal ovaries. Cystic bovine ovaries were also found to be capable of converting progesterone-4-C^{14} to testosterone-C^{14}. The testosterone yield was found to be lower by the cystic ovaries than by the normal ovaries. It is postulated that progesterone-C^{14} may follow a slightly different metabolic pathway in the cystic ovary. This is substantiated by the metabolism of progesterone-C^{14} to $\Delta^{1,4}$-androstadiene-3,17-dione-C^{14} by the cystic ovary but not by the normal bovine ovary.

295. EFFECT OF AIR TEMPERATURE ON PERFORMANCE OF GROWING-FINISHING PIGS. D. W. Mangold, T. E. Hazen, V. W. Hays and V. C. Speer, *Iowa State University, Ames.*

In a series of three experiments, 324 pigs were used to investigate the effect of air temperature on growth rate and feed efficiency of swine from weaning to market weight (12 to 200 lb). These animals were kept in complete confinement wherein the space temperature fluctuated in a normal climatic pattern with a maximum daily variation of 20° F. The level of the fluctuating pattern was controlled so that mean temperatures were spaced at approximately 10° F. intervals over the range of 30–95° F. A control group of pigs was kept in a constant 60° F. to provide a continuous base for comparing differences in animal performance under the various mean temperatures. Results indicated that no one specific mean temperature between 45° F. and 90° F. is optimum for young weaned pigs in terms of either improved feed efficiency or daily gain. For heavier pigs (50 lb. to market) significant differences were found in performance between a mean temperature of 30° F. and the 60° F. control group. At 30° F. the daily gain was 0.35 lb. lower; feed per pound of gain was 0.80 lb. higher than at 60° F.; and daily feed consumption was similar for the two groups. The daily gain of pigs from 50 to 100 lb. was 0.30 lb. less at a mean temperature of 95° F. than at 60° F., and their daily feed consumption was reduced one pound less per pig at 95° F. However slightly less feed (0.10 lb.) was required per pound of gain at the higher temperature.

296.

297. VARIATION IN PROGESTERONE CONTENT OF THE BOVINE CORPUS LUTEUM OF THE ESTRUAL CYCLE. S. E. Mares and L. E. Casida, *University of Wisconsin, Madison.*

Corpora lutea from heifers were studied at 7, 9, 11, 13, 15 and 17 days following estrus. Two corpora lutea were obtained at the same stage of different estrual cycles

from each of two heifers via supra-vaginal incision. At least one estrual cycle was observed before the second corpus luteum was removed. An analysis of variance showed a significant difference among stages in the concentration (per gm. of fresh luteal tissue) of progesterone, Δ^4pregnene-20β ol-3one, free cholesterol, and total cholesterol. The concentration of esterified cholesterol, "fast acting" sterol, DNA and RNA did not differ significantly among the stages. Progesterone concentration increased from 25.8 μg. per gm. at day-7 to 44.7 μg. per gm. at day-15, then decreased to 7.0 μg. per gm. at day-17. The concentration of 20β ol was also highest at day-15 (6.0 μg. per gm.). Free cholesterol concentration increased from 1.65 mg. per gm. at day-7 to 2.52 mg. per gm. at day-17. The total cholesterol concentration showed a similar increase. Corpora lutea weights did not differ significantly among the stages. A study of the content of progesterone, 20β ol, DNA and RNA per corpus luteum showed a significant variation in the amount of progesterone, 20β ol and DNA among the stages while the content of RNA approached significance ($P<0.10$). The variation of the RNA/DNA ratio differed significantly among stages as did the percent functional luteal cells. Significant heifer repeatabilities were found for 20β ol concentration (.65), "fast acting" sterol concentration (.75), DNA concentration (.90), 20β ol content (.55), and corpus luteum weight (.54).

298. HISTOLOGICAL AND CYTOLOGICAL CHANGES IN THE BOVINE VAGINAL EPITHELIUM. G. B. Marion and H. T. Gier, *Kansas State University, Manhattan.*

Vaginal tissue from 50 dairy cows with known reproductive histories representing all stages of reproduction were studied. During the follicular phase of the estrous cycle and the stage of gestation when the placenta is secreting estrogens, the vaginal epithelium consists of a superficial layer of secretory columnar cells and a basal layer of polyhedral cells variable in thickness. As the estrogen level increases, the superficial layer of epithelium becomes secretory, filling with highly PAS positive droplets. The nucleus becomes reduced and the cytoplasm a mass of mucus. The cell membrane ruptures extruding the cell contents, leaving the underlying layer to continue secretion. At the peak of secretion the epithelium is reduced to a single layer of high columnar cells with a partial layer of polyhedral cells below. This condition is attained in the anterior portion during estrus, and through most of the vagina in late pregnancy. The secretory activity of the superficial layer decreases and the thickness of the polyhedral layer increases posteriorly. During the luteal phase of the cycle and early in pregnancy, the superficial cells vary from a layer of non-secretory, low cuboidal cells in the anterior end to stratified squamous cells in the posterior end. During the period of low estrogic activity following parturition the epithelium is more highly stratified and the superficial layer becomes cornified and flakes off into the lumen. The presence of abnormal numbers of leucocytes is associated with pathological conditions rather than with any phase of the normal reproductive cycle.

299. POTENTIATION OF OXYTETRACYCLINE IN SWINE BY ALTERATION OF DIETARY CALCIUM SOURCES. C. M. Martin, W. C. Sherman, W. M. Reynolds and P. P. Appel, *Chas. Pfizer & Co., Inc., Terre Haute, Indiana.*

Six-week-old pigs were raised to market on rations containing approximately 0.65% calcium. Major calcium sources for different groups varied as follows: dicalcium phosphate (I), 0.60%; calcium sulfate (II), 0.60%; dicalcium phosphate—calcium sulfate (III), 0.30%–0.30%; and dicalcium phosphate—soft phosphate (IV), 0.30%–0.30%. Oxytetracycline was fed to all but one group at levels of 200 and/or 500 gm./ton. Average daily gains (lb.) and feed efficiency values at 16 weeks for the combined levels of antibiotic-supplementation on the four calcium treatments were respectively: 1.52, 3.29; 1.42, 3.74; 1.47, 3.44 and 1.42, 3.23. Feed efficiency was substantially

depressed in the $CaSO_4$ group (II); this was less evident with calcium source III. Compared with the no-antibiotic group, improvements in average daily gains (lb.) and feed efficiency values from the combined oxytetracycline levels for the four calcium sources were respectively: 0.13, 0.03; 0.04, —0.42; 0.09, —0.12 and 0.04, 0.09. Based on pooled data of all calcium sources, average blood serum oxytetracycline levels at 7 and 12 weeks of age were 2.3 times as high with oxytetracycline at 500 as at 200 gm./ton. With oxytetracycline at 500 gm./ton, average serum levels with calcium sources II, III and IV were respectively 69%, 40% and 44% higher than with source I. With 200 gm./ton, corresponding serum levels of oxytetracycline with sources II and III were respectively 78% and 122% higher than with source I.

300. INFLUENCE OF 90° F. ENVIRONMENTAL TEMPERATURE ON CERTAIN PHYSIOLOGICAL RESPONSES OF MILKING SHORTHORN HEIFERS. R. E. McDowell, J. Bond, B. T. McDaniel and E. J. Warwick, *Animal Husb. Res. Div., ARS, Beltsville, Maryland.*

Twelve heifers paired by weight were fed a high energy pelleted ration based on weight. One of each pair was kept in a psychrometric chamber at 90° F. and 21.5 mm Hg vapor pressure for 29 weeks from December to July, while pair-mates were housed under prevailing ambient conditions. The photoperiod in the chamber simulated natural daily lighting. Rate of gain and feed efficiency of the chamber group were slightly higher. Water consumption, rectal temperature and respiration rate of the chamber animals increased markedly up to the sixth week, but declined rapidly for the next ten weeks; and changes thereafter were small. The control group showed no significant change in respiration rate or rectal temperature but water intake tended to follow ambient temperature. The hair coat depth of the chamber animals decreased significantly and curvilinearly from December through July. Hair coat depth of the controls increased through March then decreased. The chamber group shed their winter hair coat in January and a secondary coat in April; whereas the control group shed only the winter coat in April. Temperature appears to have an important influence on hair coat. By multiple regression analyses changes in hair coat depth and water consumption were associated with 70% of the variation in rectal temperature but respiration rate accounted for less than 5%. These results show that water intake and hair coat depth are important in animal adaptation to hot conditions.

301.

302. EFFECTS OF FEEDING HYGROMYCIN B ON THE REPRODUCTIVE ABILITY OF GILTS AND SOWS. T. M. Means, W. P. Waitt and C. E. Jordan, *Eli Lilly and Company, Agricultural Research Center, Greenfield, Indiana.*

Hygromycin B did not interfere with the reproductive ability of gilts and sows fed under a variety of treatment regimes. A total of 56 litters from control sows and 79 litters from treated sows were involved in this study. One group received feeds which contained 12 gm. hygromycin B per ton from weaning through 100 lb. liveweight, then were retreated during the last 8 weeks of two consecutive gestation periods. A second group received hygromycin B from weaning to market weight only. Another, which had also received hygromycin B from weaning to market weight, was retreated the last 8 weeks of gestation. A group which had not received hygromycin B during the growing period was retreated for 8 weeks prior to breeding and retreated the last 8 weeks of gestation. Another group of gilts which had not received hygromycin B from weaning to market weight, was placed on feeds which contained 12 gm. hygromycin B per ton continuously over a 20-month period. Three litters were farrowed by this group during the treatment period. Conception rate, litter size, number of stillborn pigs, and average birth weight were not affected by hygromycin B treatments. No adverse effects were noted in the pigs farrowed from hygromycin B treated dams.

303. FERTILIZATION CAPACITY OF BOVINE SPERM DILUTED WITH ANTISERA AGAINST SPERM AND RED BLOOD CELLS. A. C. Menge, W. J. Tyler, W. H. Stone and L. E. Casida, *University of Wisconsin, Madison.*

Six heifers were inseminated with bull semen that had been diluted with antiserum from a heifer immunized against the sperm of the bull. Five heifers returned to heat an average of 21 days after breeding while the sixth had a degenerating embryo 42 days postbreeding. Two additional heifers were bred with semen diluted with the "normal" serum of the heifer (obtained before immunization) and another two with semen diluted by a modified Krebs solution. Normal appearing embryos were found 42 days after insemination in the first case and 14 days after in the second. In the second part of the experiment rabbit anti-bull-sperm serum was used as the diluent of the bull semen. Six heifers were bred and they all returned to heat within 19 to 29 days postbreeding. Three of the heifers were rebred with semen diluted by rabbit antiserum and the other three with semen diluted by rabbit "normal" serum. On the third day postbreeding two of the three heifers in the latter case had fertilized ova while all in the former case had unfertilized ova. An additional two heifers each were bred with semen diluted with rabbit anti-bull-sperm serum that had been absorbed with either the sperm cells or the red blood cells of the bull. Fertilized ova were recovered from the two heifers inseminated with semen diluted with sperm-absorbed antiserum while the other two heifers had unfertilized ova. In a final part of the experiment two pools of anti-red-blood-cell sera were obtained against the red blood cells of two bulls. The semen of each of these two bulls was diluted with the proper antiserum and all of the five heifers bred had a fertilized ovum.

304. HORMONES AND MAMMARY GLAND GROWTH. Richard C. Moon, *University of Tennessee, Memphis.*

It is well known that considerable variation exists between animals in degree of mammary gland lobulealveolar development. Since mammary gland growth is known to be under the influence of a number of hormones, an inadequate secretion of one or more would result in suboptimal growth. Experiments were designed to determine whether the addition of growth hormone (GH) to a previously determined "optimal" hormone regimen of estradiol-benzoate (EB), progesterone (P) and thyroxine (T4) would enhance mammary gland growth in ovariectomized rats. Desoxyribonucleic acid (DNA) content of the abdominal-inguinal glands was used as an index of a mammary gland growth and the presence of alveoli confirmed by whole mount examination. Mammary gland DNA of rats receiving daily injections of GH for 19 days was comparable to that of ovariectomized rats. DNA of animals treated with 2 μg. EB, 6 mg. P, 3 μg./100 gm. T4 and 0.5, 1, 1.5, or 2 mg. GH was significantly greater than rats receiving only EB, P and T4. A daily GH level of 1 to 1.5 mg. appears "optimal" under these conditions. Rats injected with EB, T4 and GH also exhibited considerable alveolar development. These data suggest that an inadequate secretion of GH may limit mammary gland growth and this, in turn, may be an important factor in the subsequent degree of lactation.

305. EFFECTS OF FEEDING 17-ACETOXYPROGESTERONE (PRODOX) TO PREGNANT GILTS AND SOWS. M. C. Morrissette, J. A. Whatley and L. E. McDonald, *Oklahoma State University, Stillwater.*

Twenty-one cross bred yearling sows were double mated and divided into one control group and two treatment groups. After breeding, the first treatment group was fed 0.5 mg. of 17-acetoxyprogesterone and 0.25 gamma of diethylstilbestrol per pound of body weight daily. The second treated group was fed 1.0 mg. of 17-acetoxyproges-

terone and 0.5 gamma of diethylstilbestrol per pound of body weight daily. All sows were slaughtered at the 25th day of gestation to determine embryonic mortality. A mortality of 37.90% occurred in the control group, 18.26% in the first treated group and 10.93% in the second treated group. This reduction in mortality was significant (P=.01). In a second experiment, 30 cross bred gilts were double mated and divided into one control and one treated group. After breeding, the treated group was fed 1.0 mg. of 17-acetoxyprogesterone and 0.5 gamma of diethylstilbestrol per pound of body weight daily. All gilts were slaughtered on the 40th day of gestation to determine embryonic mortality. A mortality of 25.69% occurred in the control group and 23.00% in the treated group. This difference in mortality was not significant. No side effects due to treatment were observed in the sows and gilts nor in their embryos.

306. ESTRUS, OVULATION AND FERTILITY IN GILTS SUBSEQUENT TO THE ORAL ADMINISTRATION OF 6-METHYL-17-ACETOXYPROGESTERONE. J. E. Nellor, J. E. Ahrenhold, N. L. First and J. A. Hoefer, *Michigan State University, East Lansing.*

One hundred and thirty-four purebred and crossbred gilts, weighing 190 to 310 lb. were included in the study. The gilts were fed from 0.4 to 1.6 mg. of 6-methyl-17-acetoxyprogesterone per pound body weight daily, by twice-a-day feeding, in an average of 3 to 7 lb. of daily ration per gilt. The duration of treatment was from 7 to 26 days. The development and functional life of swine corpora lutea were apparently not influenced by the dosages administered. A high degree of control of the time of estrus and ovulation was obtained when gilts were fed 0.5 mg. of 6-methyl-17-acetoxyprogesterone per pound body weight daily, by twice-a-day feeding, for 15 days, in a limited amount of ration (an average of 3 to 4 lb. daily per gilt). Eighty-seven percent of the gilts came in estrus 4 to 5 days after the end of progestational treatment. The conception rate in gilts bred at the controlled estrus was 78%. The estimated ovulation rate at the controlled estrus (14.5 per gilt) and the number of fetuses recovered 35 days following service at the controlled estrus (11.1 per gilt) were not significantly different from those in comparable age and weight control gilts (11.5 and 9.3, respectively).

307. INFLUENCE OF ORAL ADMINISTRATION OF 6-METHYL-17-ACETOXYPROGESTERONE ON FOLLICULAR GROWTH AND ESTROUS BEHAVIOR IN BEEF HEIFERS. J. E. Nellor, J. E. Ahrenhold and R. H. Nelson, *Michigan State University, East Lansing.*

The progestational activity of 6-methyl-17-acetoxyprogesterone was determined when the compound was administered as part of the normal ration to 77 mature heifers at various stages of the estrous cycle. The heifers were treated individually or in groups and received from 0.2 to 0.8 mg. of 6-methyl-17-acetoxyprogesterone per pound body weight daily, by twice-a-day feeding, for 15 to 20 days. Estrus was inhibited at all levels of treatment regardless of the stage of the estrous cycle when treatment commenced. Ovulation without estrus occurred at the 0.2 mg. dosage level. Levels of progestational treatment above 0.4 mg. per pound body weight daily resulted in complete inhibition of follicular growth during the treatment period. The progestational influence upon the Fallopian tubes and endometria of the uteri was marked with dosage levels of 0.4 mg. or greater. The progestational endometrium was maintained for the duration of treatment although the ovaries contained no active corpora lutea. The occurrence of estrus subsequent to treatment was dependent upon the level of progestational treatment administered. Estrus occurred 4 to 5 days after the end of treatment with 0.4 mg. and the duration from the end of treatment to the start of estrus increased as the dosage increased.

308. RUMEN, RECTAL AND SKIN TEMPERATURES OF SHEEP UNDER SUBTROPICAL CONDITION (OAHU, HAWAII). Terrell L. Noffsinger, Kenneth K. Otagaki and Clifton T. Furukawa, *University of Hawaii, Honolulu.*

One intact and two rumen-fistulated native yearling wethers were used in the determination of rumen, rectal and skin temperatures of native sheep. Rectal temperatures from Targhee sheep (four rams, two ewes and two lambs; ewes and rams were imported six months earlier, December 1959, from Dubois, Idaho) were compared to the temperatures of native sheep. All the animals were maintained under normal Oahu environmental condition, which was shade temperature 79.0° F. and 71% relative humidity. In the native sheep, skin temperature (taken about one inch off the mid-line at the first lumbar vertebra) ranged from 95.9° to 100.8° F., with a mean value of 99.3° F. Mean rectal temperature was 103.0° F. with a range from a minimum of 100.0° F. to a maximum of 105.0° F. Rumen temperature averaged 103.5° F. but ranged from a low of 96.0° F. to a high of 106.1° F. During a 36-hour fasting period both rumen and rectal temperatures showed a characteristic diurnal cycle. Lowest temperatures were recorded during the evening, night and early morning with a maximum value occurring between 1400 and 1600 hours local time. A comparison of 30 measurements of rectal temperature of Targhee sheep (from Mainland) with simultaneous measurements of native sheep showed a difference of more than 1° F.—Mainland over native. Mean rectal temperatures were: native wethers, 102.3° F.; Targhee ram, 103.6° F.; Targhee ewes, 103.8° F.; Targhee lambs, 104.4° F. These data suggest that native sheep have made an adjustment to subtropical condition by a marked decrease in metabolism and a resultant lower body temperature in comparison to sheep recently imported from cooler areas.

309. EFFECT OF THE STRESS OF TRANSPORTATION AND CHANGE OF SURROUNDINGS ON FETAL MORTALITY IN GILTS. James C. Nofziger and M. E. Ensminger, *Washington State University, Pullman.*

Forty Palouse gilts were divided into 4 groups of 10 gilts each. At approximately 30 days of gestation the groups were subjected to the stress of either transportation by truck for a distance of 160 miles, a change in surroundings by movement to a new pasture inhabited by strange sows or a combination of both. One group serving as negative controls was left in familiar surroundings. Ten days after stressing, all gilts were slaughtered and their reproductive tracts examined for any effects of the treatments upon fetal mortality. The number of ovulations, implantations and the number of live and dead fetuses were determined for each gilt. Ovulations ranged from 10 to 20, and averaged 13.9, 13.2, 14.9 and 15.7 for the four treatment groups. Number of implants ranged from 2 to 18 and averaged 10.9, 8.1, 11.9 and 11.7 for the four groups. Live fetuses 10 days after treatment ranged from 1 to 17 and averaged 9.8, 7.7, 10.6 and 11.7 for the four treatments. There was no difference due to treatment in the per cent of implanted embryos dead at the time of slaughter.

310. PROGESTERONE LEVELS IN CORPORA LUTEA, OVARIES AND ADRENALS OF SOWS PREGNANT 35 TO 45 DAYS. James C. Nofziger, Ralph E. Erb and Fred Stormshak, *Washington State University, Pullman.*

Thirty-six first litter Palouse sows were slaughtered at 35 to 45 days of gestation. Weights of ovaries, corpora lutea and adrenal glands and number of corpora lutea were determined. The corpora lutea were expressed from the ovaries and chromatographic determination of progesterone was made on the corpora lutea, ovarian stroma and adrenals. The correlation of number and mean weight of corpora lutea was $-.423$, $P<0.01$. A significant relationship between the number of corpora lutea and the concentration of progesterone per corpus luteum and between the total weight of luteal tissue and the total luteal progesterone was observed ($r=-.375$, $P<0.05$ and 0.328, $P<0.05$,

respectively). No significant relationship between the total luteal progesterone and the progesterone content of the ovarian stroma was noted ($r=0.167$, $P>0.05$). The correlation of total luteal progesterone and total adrenal progesterone was 0.732, $P<0.01$; however, no significant relationship existed between the concentration of progesterone per gram of luteal and adrenal tissues ($r=0.0104$, $P>0.05$). The total adrenal progesterone was not related to the weight of the adrenal glands between sows ($r=0.137$, $P>0.05$).

311. A METHOD FOR THE STUDY OF PANCREATIC SECRETION IN THE BABY PIG. J. C. Pekas, V. W. Hays, A. M. Thompson, J. D. Jones and V. C. Speer, *Iowa State University, Ames.*

A method for the study of the development of pancreatic digestion by the baby pig by direct cannulation of the pancreatic duct has been developed. The animal is partially immobilized by use of a harness which limits animal movement within the cage. The experimenter can collect the secretion without handling the animal. Feces and urine are collected separately. The uncontaminated secretion is available for any analysis desired; however, in this particular study, protease, lipase, and amylase activities were assayed, the buffering capacity titrated, and the pH determined. Kymographic recordings of pancreatic secretion rates indicate that the secretion is closely associated with the time the animal eats. The ranges of values established by use of this method up to date are as follows: pH, 7.79–8.20; protease, 0.013–0.60 mg. 3 × U.S.P. pancreatin equivalents per ml. of secretion; amylase, 54–772 mg. maltose equivalents per ml. of secretion; lipase, 0.033–0.353 meq. KOH equivalents per ml. of secretion. Between 0.00 and 0.019 meq. of acid were required to titrate 1 ml. of pancreatic secretion to the phenolphthalein end point. Secretion rates have been found to vary between 0.0 ml. and 11.0 ml. per hour. These values were established with animals between 4 and 5 weeks of age.

312. COMPARATIVE BIOLOGICAL ACTIVITY OF SEVERAL GOITROGENS IN THE RAT. G. W. Pipes, J. A. Grossie and C. W. Turner, *University of Missouri, Columbia.*

Since previous studies had suggested that large amounts of the goitrogen, tapazole, might increase the apparent thyroxine secretion rate in the rat, it was decided to determine the minimal dose of three goitrogens, tapazole, carbimazole, and thiouracil, necessary to block iodine uptake by the thyroid gland. Injections of 0.3 mg. of carbimazole per 100 gm. body weight did not completely block I^{131} uptake, but blockage was complete at 0.375 mg.; tapazole at 0.375 mg. suppressed thyroid uptake of I^{131} but not at the 0.25 level. Six mg. of thiouracil per 100 gm. body weight did not inhibit I^{131} uptake, but inhibition was complete with 9 mg. Carbimazole or tapazole was found to be over twenty times as potent in the rat as was thiouracil.

313. COMPARISON OF THYROID SECRETION RATES OF DAIRY COWS AS DETERMINED BY SEVERAL METHODS. T. B. Post and J. P. Mixner, *New Jersey Agricultural Experiment Station, Sussex.*

Four non-lactating dairy cows (Holsteins and Guernseys) were used to make within animal comparisons of thyroid secretion rates by radioisotope and chemical thyroxine turnover methods (J. Animal Sci., 18:1566. 1959; Proc. XV International Dairy Congress, 1:20. 1959) and by the thyroxine inhibition of thyroidal-I^{131} release method (J. Animal Sci., 11:794. 1952; J. Dairy Sci., 40:340. 1957). Duplicate radioisotope and chemical thyroxine turnover method determinations and a single thyroxine inhibition of thyroidal-I^{131} release method determination were performed in each animal over a period of three months. The mean daily thyroxine secretion rates per 100 lb. body

weight for the radioisotope thyroxine turnover, the chemical thyroxine turnover, and the thyroxine inhibition of thyroidal-I^{131} release methods were 0.144, 0.135, and 0.129 mg., respectively. Differences among the various method mean daily thyroxine secretion rates were not significant, statistically. These results indicate that the various methods of estimating thyroid secretion rates give similar results when compared on a within animal basis. Based upon duplicate determinations, the standard error of a single determination of daily thyroxine secretion rate per 100 lb. body weight for the radioisotope and chemical thyroxine turnover methods were 0.014 and 0.015 mg., respectively, while the corresponding coefficients of variations for single determinations were 9.7 and 11.4%, respectively. Thus the precision of making the thyroxine turnover methods determinations for thyroxine secretion rate was considered to be fairly good.

314. THE EFFECT OF HYPOTHALAMIC LIPIDS ON THE REPRODUCTIVE SYSTEM. H. A. Poston, L. C. Ulberg and J. A. Santolucito, *North Carolina Agricultural Experiment Station, Raleigh.*

Twenty-five mg. of lipid extracted from bovine hypothalamus and administered in cottonseed oil (0.5 ml.) as a single subcutaneous injection resulted in depression of body, reproductive tract and pituitary gland weights in male and female rats and mice. For example, in one trial with seven female mice (21–23 days) the following percent weight reductions (96 hr. post-injection) were obtained: body, —40; ovaries, —10; uterus, —51; adrenals, —15. Similarly, for 14 male mice: body, —13; testes, —36; ventral prostate, —28; seminal vesicles, —38; pituitary, —17; adrenals, —8. The above weight depressions, though some were slight, were consistent. Of interest was the question of whether this effect could interfere with reproductive performance. Therefore, two groups of 10 virgin, albino, female rats (Charles River) were mated and administered either 4 or 11 daily injections (15 mg./injection) of lipid extract beginning with day of mating. Controls received daily injections of 0.5 ml. cottonseed oil. No apparent influence on ovulation rate or on embryonic development to time of implantation was observed. However, by day 12 of gestation, there was an average of 3.6 and 1.2 more corpora lutea than fetuses in the treated and control groups, respectively. Body and reproductive tract weight depressions were similar to those of the immature single-injection mice.

315. ABSORPTION OF THYROXINE FROM SKIN IN CATTLE. B. N. Premachandra and C. W. Turner, *University of Missouri, Columbia.*

Virtually no information is available on the rate of subcutaneous absorption of thyroxine from the skin into the blood stream in cattle. Since the determination of thyroxine secretion rate by replacement techniques by several workers has involved the 24-hour subcutaneous administration of thyroxine, it was rather interesting to study the kinetics of thyroxine absorption. Mature dairy animals of several breeds were injected with 300 μc. I^{131}-labeled thyroxine in the thigh region and blood samples drawn every 5 minutes for the first 30 minutes and every hour thereafter for 24 hours. There was a steady increase in radioactivity in blood for the first 6 hours, and thereafter the rate of increase began to decline sharply in an exponential fashion. At 24 hours very little increase in radioactivity was observed and a plateau could be seen in this region. Therefore, the maximum absorption, both in magnitude as well as in rate, appeared to be in the first 6 hours, and a diphasic exponential curve could be described for the overall 24-hour absorption. No marked breed differences were noted in absorption rate. The relatively quick absorption of thyroxine would therefore tend not to introduce an appreciable error in the 24-hour estimated equivalent thyroxine secretion rates by replacement techniques. The latter observation is emphasized to impress that appreciation has been given to the fact that the physiological process of thyroxine secretion is such that thyroxine is secreted gradually or there are a number of small discrete secretions rather than being secreted all at one time.

316. EFFECT OF PROGESTERONE ON THE ESTROUS CYCLE AND PITUITARY GONADOTROPHIN CONTENT OF THE BEEF HEIFER. D. E. Ray and R. M. Melampy, *Iowa State University, Ames.*

Twenty-seven Hereford heifers exhibiting normal estrous cycles were divided into three groups and given a single injection of 0.76 mg. REPOSITOL progesterone (Pitman-Moore Co.) per lb. body wt. at three stages of the estrous cycle, 0 (heat), 8 and 16 days postestrum. From each group three animals were slaughtered 8 days and three 16 days post-injection. The remaining three animals in each group were allowed to return to estrus and were slaughtered 2–4 days thereafter. Five non-treated control heifers were also slaughtered at three stages of the estrous cycle, 1, 8, and 16 days postestrum. Pituitary gonadotrophin potencies (F.S.H. and L.H.) were estimated for all animals. Lactogenic hormone levels were evaluated only in the control animals. Estrus was observed 12–14 days following progesterone injection at heat, 16–19 days after injection at day 8, and 14–16 days following injection at day 16 of the cycle. No significant differences in pituitary F.S.H. or L.H. content were observed in the progesterone injected heifers, whereas significant differences were obtained between the control and progesterone treated animals in both F.S.H. and L.H., the control pituitaries being higher in both gonadotrophins. Of the control heifers, those slaughtered 1 day postestrum assayed a significantly lower level of L.H. than at 8 or 16 days postestrum, although no significant differences between stages were obtained for F.S.H. or lactogen.

317.

318. PANCREATIC ISLET CHANGES IN SHEEP IN RESPONSE TO CHRONIC INTRAVENOUSLY INFUSED GLUCOSE. Perry W. Riley and James M. Boda, *University of California, Davis.*

Nine sheep, intravenously infused with glucose, 4 of them force-fed, and 5 non-force-fed, have been compared with 11 control animals, either pair-fed and pair-infused (without glucose) or merely pair-fed. These comparisons have shown: (1) Glucose infusions caused pancreatic islet hypertrophy in fed, healthy sheep and degenerative signs in the islets of non-fed sheep. (2) Severe restriction of feed intake caused reduced glucose tolerance in nonglucose-infused sheep. Reduction of tolerance was greatest in noninfused sheep, least in glucose-infused sheep, and intermediate in the control-infused (without glucose) sheep. (3) Glucose infusion into sheep with feed intake maintained either orally or via rumen fistulae in the absence of appetite caused increased glucose tolerance in 4 of 5 cases. (4) Glucose infusion caused elevated glycogen stores in fed and non-fed sheep irrespective of pancreatic islet condition. (5) The elevation of blood sugar caused anorexia. Hyperglycemia destroyed appetite in 4 animals the first day; in 6 others appetite was partially maintained for 6 to 13 days. The imposition of a glucose load by continuous infusion elicits changes which indicate that some adaptive responses are necessary. The required metabolic adjustments have been better accomplished by the force-fed sheep than by the non-force-fed ones. Apparently even in the absence of appetite the force-fed rumen can be maintained in a functional state that allows it to synthesize nutrients for absorption in sufficient quantity and balance to permit the improved adaptive response.

319. PRACTICAL CONSIDERATION IN SWINE REPOPULATIONS. Ben E. Sheffy, *Cornell University, Ithaca, New York.*

Swine repopulation with specific pathogen-free pigs is catching the imagination of swine producers. The methods of producing initial or primary animals of this type

of pig are now possible and practical. The methods of management and the housing required to keep these pigs specific pathogen free, particularly with reference to transmissible gastroenteritis are not clearly understood. Two basic methods are possible: (1) Under laboratory conditions for research purposes, these pigs are then continued to be raised without drugs or immunizing procedures in strict isolation so that no contact with disease is encountered. This requires special precautions which today may not be practical for commercial pig production. (2) The alternate method is to do so by using drugs and by vaccinating these pigs against the diseases we can immunize them against and to use management practices which minimize the chances of reinfecting them with those we cannot immunize against. The Cornell Veterinary Virus Research Institute has produced a specific pathogen free herd of swine and has maintained this herd as such since 1956 employing basic method 1.

320.

321.

322. SURGICAL RECOVERY OF BOVINE TUBAL OVA. A. M. Sorensen, Jr., D. C. Kraemer and W. F. Davis, Jr., *Texas Agricultural Experiment Station, College Station.*

Twenty laparotomies were performed to develop a technique for recovery of recently ovulated bovine tubal ova. Nineteen oviducts were flushed and seven ova were obtained. Three of the ova were recovered in seven flushing trials with oviducts excised through laparotomy. Four of the ova were recovered in twelve flushing trials with intact oviducts exposed through laparotomy. Six of the ova were over 30 hours old when recovered and one was approximately 13½ hours old. It was found that a paravertebral lumbar block using xylocaine gave an anesthetic response that was superior to the infiltration of the operating area with xylocaine. When 2.9% sodium citrate solution was used as a flushing fluid there was less coagulation of the fluid than when physiological saline was used. This reduced coagulation enhanced the searching of the fluids for location of the ovum. Orientation of the opening of the oviduct in such a manner that the flushing fluid flows directly into the collecting glass without passing over the infundibular tissue appears to be helpful in ova recovery.

323.

324. WOOL CHARACTERISTICS OF WEANED LAMBS AS INFLUENCED BY THE ADRENALS AND GONADS. G. M. Spurlock and M. T. Clegg, *University of California, Davis.*

Seventy weaned lambs were allotted at random within sexes to eight treatment groups and injected intramuscularly twice weekly as follows: 8 wethers received 5 gm. of perthane (2,2-bis(paraethyl phenyl)-1, 1-dichloroethane) in 10 cc of vegetable oil; 8 wethers, 100 mg. testosterone propionate in 3 cc vegetable oil; 7 wethers, 5 gm. perthane in 10 cc vegetable oil plus 100 mg. testosterone propionate in 3 cc vegetable oil; 7 wethers, 100 mg. cortisone acetate in aqueous solution, 7 wethers, 3 cc vegetable oil; 10 ovariectomized ewes, 100 mg. testosterone propionate in 3 cc vegetable oil; 12 ovariectomized ewes, 3 cc vegetable oil; 11 intact ewes, 3 cc vegetable oil. The test period extended over 175 days and animals were maintained in dry lot on alfalfa hay *ad libitum*. Shoulder areas of the lambs were shorn prior to treatment and again at the end of the trial. Clean fiber production per unit skin area was recorded for wool grown over the treatment period. Mean fiber diameter, fiber length, and width and

depth of staple crimp were also measured. Width of crimp was significantly ($P<.05$) greater in cortisone-treated wethers than in controls. Combining testosterone-treated wethers and ovariectomized ewes versus their controls showed that testosterone significantly ($P<.05$) lowered clean wool production. None of the other treatments significantly affected the wool characteristics studied. Trends in means in fiber diameter and clean wool production in cortisone-treated wethers were consistent with the decrease in protein growth shown by gain and carcass composition data on these lambs.

325. EEG AS A NEUROLOGICAL INVESTIGATION OF MUSCULAR DYSTROPHY IN LAMBS. W. Sterner, A. Sheff, E. S. Erwin and L. Tureen, *St. Louis University Medical School, St. Louis, Missouri, and Monsanto Chemical Company.*

Nutritional muscular dystrophy in animals has been considered by most authorities to be a primary myopathy without nervous system involvement. However, some investigators report possible causal relationship between certain muscular dystrophies and the nervous system. The majority of clinical and experimental investigations dealt with histopathological, biochemical, and electromyographical techniques. An attempt was made in our experiment to use the EEG as a means of clinical investigation in muscular dystrophic lambs. It was hoped that eventual neuropathological brain changes could be recorded and related to the severity of the symptoms of muscular dystrophy. Three lambs were fed a dystrophy producing diet, and three lambs served as control from one day of age. Four to six silver electrodes were implanted extradurally in the frontal, temporal, and occipital areas of the skull. Bipolar recordings were recorded at weekly intervals for 6–8 weeks, covering all clinical stages of muscular dystrophy. Clinical examination, CBC, EKG, histopathology, and SGOT determinations were used to establish an accurate diagnosis of the dyscrasia. Under the conditions of the experiment no correlation between severity of clinical symptoms and electroencephalographic tracings could be demonstrated, either with normal, photostimulation, or metrazol activation recordings. Of physiological interest is the presence of definite brain wave patterns; that is, (1) the "drowsy" pattern with high voltage and low frequency waves from 3–5/sec., resembling the theta band in human subjects, (2) the "alert" pattern with low voltage and high frequency waves from 8–14/sec., resembling the alpha bands, (3) the "photic activation" pattern produced optimally by frequencies between 6–8 flashes/sec., (4) the "metrazol activation" pattern characterized by bilateral high voltage spikes.

326. RESPONSE OF SWINE TO SURGICAL AND RADIOIODINE THYROIDECTOMIES. E. V. Stromlund, E. F. Reber, L. E. St. Clair and R. Kodras, *University of Illinois, Urbana.*

Six pigs (33–50 lb.) were thyroidectomized by radioiodine. The average growth of the pigs was 0.92 lb. per day (range 0.78–1.15) for an 80-day experimental period. Thyroid uptakes of radioiodine at the end of the period by three pigs fed a ration containing 0.54 ppm. added iodine were 0.2, 0.2, and 3.5%; and by three pigs fed the ration with no added iodine were 6.8, 8.0, and 8.4. Red blood cell uptake of L-triiodothyronine averaged 16.7% (range 16.1–17.7). The animals were necropsied after the radioiodine uptake measurement and thyroid tissue was located by a Geiger counter. Connective tissue was increased at the site of the thyroid gland. Small amounts of thyroid tissue remaining consisted of a few follicles and atypical columnar cells. Fifteen pigs (15–67 lb.) were surgically thyroidectomized. Average growth of the pigs was 0.51 lb. per day (range 0.07–1.05). Thyroid uptake 60–80 days after thyroidectomy averaged 20.1% (range 11.4–27.3). Red blood cell L-triiodothyronine uptake averaged 15.6% (range 13.3–17.8). Several small pieces of thyroid tissue were found in each pig. Activity was indicated in the pieces by the presence of columnar cells and a few follicles.

The average weight of thyroid tissue was 1.22 gm. for surgical thyroidectomized as compared to 4 gm. per 50 lb. for nonthyroidectomized pigs. Radioiodine thyroidectomy is more complete than surgical thyroidectomy. The data indicate a small amount of thyroid tissue will maintain reasonable growth.

327. AN IMMUNOLOGICAL TECHNIQUE FOR QUANTITATIVELY MEASURING GROWTH HORMONE IN BOVINE BLOOD. Allen Trenkle, Wise Burroughs, R. M. Melampy and L. Y. Quinn, *Iowa State University, Ames.*

An immunological assay technique based upon complement fixation was developed which had sufficient precision and sensitivity to measure amounts of growth hormone present in 0.2 ml. of bovine serum. Antibodies for growth hormone were obtained by immunizing rabbits against bovine growth hormone with the aid of Freund's adjuvant. Standard curves were established by plotting optical density of hemoglobin released from red blood cells during hemolysis using quantities of purified growth hormone ranging from 0 to 0.15 mcg. No reactions were noted with certain bovine plasma fractions or when ovine lactogenic hormone was used in place of bovine growth hormone. Also this immunological method gave similar estimates of growth hormone to those obtained using the rat tibia test when assaying a bovine plasma fraction relatively high in growth hormone content. Based upon these studies the assay was considered to be specific for growth hormone. Rather limited application of this immunological technique indicated that growth hormone concentrations in serum from non-lactating and non-pregnant mature cows, two-year old heifers and one-year old heifers were 5.0, 35.6 and 73.8 mcg. per 100 ml. of serum respectively. An assay of serum samples from mature lactating cows and their ten-week old bull calves revealed individual animal differences in the concentration of circulating growth hormone but no differences which could be specifically related to the age of the animals.

328. LIMITING EFFECTS OF UNDERFEEDING DURING GROWTH ON SPERM PRODUCTION OF MATURE BULLS. N. L. VanDemark, G. R. Fritz, L. L. Ewing and R. E. Mauger, *University of Illinois, Urbana.*

From 2 to 46 months of age, two Holstein bulls were fed 60% and two controls 100% of the TDN recommended by Morrison (21st ed.). Weights and measures were taken monthly and partial exhaustions (10 ejaculates in 90 minutes) following an initial were made at 1, 4, 7, and 13-day intervals beginning at 12 months of age and subsequently repeated every 4 months. Body weight, testis size, and wither height of the underfed bulls consistently lagged behind the controls and were 79, 74, 95%, respectively, at 46 months of age. Sperm production by the underfed bulls averaged 77% that of the controls for collections at 36, 40, and 44 months of age. The rations were reversed from 46 to 58 months of age so the controls received 60% and the underfed bulls 100% of the recommended TDN. Changing the ration provoked an appreciable increase in body weight, some increase in testis size, but no change in wither height in the previously underfed bulls. The means of these measures at 58 months of age were 97, 80, 96%, respectively, of the controls. Sperm production of both groups decreased slightly following the ration change. However, the original underfed bulls on the 100% TDN level averaged only 79% the number of sperm produced by the controls on a 60% TDN intake. Further evidence of the limiting effects of underfeeding during growth on sperm production at maturity was shown in the rate of sperm replenishment after depletion. At the 1, 4, and 7-day collection intervals during the year prior to changing the rations to the 100% TDN level, the underfed bulls averaged 6.2, 11.5, and 16.9 $\times$ 10^9 sperm and 6.0, 9.6, and 15.6 $\times$ 10^9 sperm, respectively, in the year after.

329. PROLONGED CONTROL OF PASTURE BLOAT BY ORAL ADMINISTRATION OF ANTIBIOTICS. H. H. Van Horn, Jr., P. H. Hartman, N. L. Jacobson, A. D. McGilliard, P. R. Shellenberger and S. M. Kassir, *Iowa State Univeristy, Ames.*

Four groups of cattle (15–16 animals each, average initial weight 575 lb.) were allowed to graze alfalfa pasture from 7 to 10 a.m. and 3:30 to 6:30 p.m. Group I served as control, Groups II and IV received antibiotics in grain (average of 2 lb. per animal daily) and Group III received antibiotics in drinking water. Antibiotics were fed to Group II in rotation, each antibiotic being fed singly for 7 days. The weekly sequence of antibiotics and the average amount per animal daily were: penicillin (P), 35 mg.; erythromycin (E), 70 mg.; tylosin (T), 70 mg.; chloramphenicol (C), 140 mg.; oxytetracycline (O), 140 mg.; and streptomycin (S), 70 mg. Good control of bloat resulted during this 6-week rotation, although bloat in the control group was mild during the streptomycin period. When the cycle was repeated, control was not adequate in some cases, indicating that "resistance" to some of the antibiotics had not disappeared completely after 5 weeks. Group III was fed P, E, T and C sequentially in water. Results indicated this may be an acceptable method of administration provided the antibiotics are reasonably stable and sufficiently water soluble. Group IV received five antibiotics in combination at the following daily rates per animal: P, 20 mg.; E, 35 mg.; T, 35 mg.; C, 50 mg.; and O, 50 mg. After 2 weeks some bloat appeared and the levels were doubled. Excellent control resulted during the next 6 weeks. Control continued for a subsequent 4-week period but during this time bloat declined in the control group; thus conclusions beyond 8 weeks cannot be made. The animals showed no adverse effects from any of the antibiotic feeding schedules.

330.

331.

332. EFFECT OF DEPTH OF PROBE INSERTION AND VOLTAGE ON RAM SEMEN COLLECTED BY ELECTRO-EJACULATION. E. P. Warren, A. S. Todd and B. Fakhrnea, *University of Georgia, Athens.*

A 3 x 3 factorial experiment of completely randomized design was conducted to study effects of depth of probe insertion (6, 8 and 10 inches) and voltage (8, 12 and 16 volts). A 2-ring probe which had been constructed previously was used. Six yearling Suffolk rams were allotted into three groups with each group receiving a different treatment at each of nine collection periods. Criteria used in evaluating treatments were volume, sperm concentration, motility and general appearance of ejaculates and number of stimulations required for collection. Voltage did not significantly affect any of the five criteria. Depth of probe insertion and a highly significant effect on semen volume, the shallower depth producing the largest volume of ejaculate. Effect of depth of probe insertion on number of stimulations required for ejaculation approached significance, the shallower depth tending to require fewer stimulations. Mean values for 6-, 8- and 10-inch depths were, 2.01, 1.48 and 1.18 ml. and 3.5, 4.1 and 5.7 stimulations, respectively. A highly significant interaction was found between voltage and depth with respect to volume and a similar significant interaction occurred with respect to sperm concentration. Apparently, increasing voltage tended to counteract the detrimental effects of deeper probe insertion. Other interactions were not significant. There were no differences between groups of rams with respect to any of the criteria. A highly significant difference with respect to motility and general appearance was found between rams receiving the same treatment.

SUBJECT INDEX FOR ABSTRACTS OF PAPERS AT THE ANNUAL NATIONAL MEETING

Note: Abstracts are referred to by number

A

Absorption and secretion
  In alimentary tract of sheep, 88
Adrenalectomy, effect in the bull, 268
Alfalfa-brome silage
  Digestibility of, 144
Alfalfa hay
  Conditioned, for wintering calves, 241
Alfalfa hay factor
  Required by stomach worm of sheep, 215
Amino acids
  For early-weaned pigs, 81
  Limiting, in swine rations, 98
  Mixtures of, for baby pigs, 111
Annual crops as pasture for lambs, 256
Anthelmintic for lambs, 253
Antibiotics
  For growing-finishing swine, 125
  In control of pasture bloat, 329
  Intermittent feeding of, to pigs, 207
  Value of, for swine, 210
  Virginiamycin, for swine, 82
Arborization in cervical mucus of sow, 262

B

Beef, broiled ground
  Fat content on palatability, 44
Beef carcasses
  Yield of retail cuts, 63
Beef characteristics
  Effects of freezing and storage on, 50
Beef, flavor
  Effects of pasture forages on, 72
Beef rib steaks
  Firmness, tenderness and fat content, 66
Beef, sensory tenderness analyses
  Hydroxyproline content and Kramer shear, 65
Bloat
  Control of pasture, by antibiotics, 329
Bovine tubal ova, surgical recovery, 322

C

Cafeteria studies with calves
  Effect of number of choices, 160
Calcium
  Effect on selenium-75 in swine, 94
  Metabolism in pig, 84
  Relation of, to cellulose digestion, 121
  Requirement of baby pig, 159
  Studies with baby pigs, 225
Calorie: protein ratios
  Evaluation of, for swine, 86
Cancer eye
  Influence of sunlight on, 1
Carcass and live hog relationships
  Between boar, barrow and gilt, 76
Carcass and productive traits
  Sex effects on, in beef calves, 58
Carcass characteristics
  And acceptability of pork cuts, 62
Carcass characteristics, calves
  Factors affecting grass and milk-fed, 73
Carcass characteristics, hogs
  Effect of age at slaughter, 71
Carcass characteristics, lamb
  Effect of antemortem stress on, 53
  Fine wool and crossbred, 55
Carcass composition, lambs
  Effect of breed-type and feed, 57
  Use of K^{40} to determine, 56
Carcass grade, cattle
  Effect of protein, 68
Carcass value
  Ham equivalent as an index, 75
Carcasses
  Cutting yield and loin eye in hog, 9
Carcasses, beef
  Estimates of separable lean in, 43
Castration, delayed
  Influence on gain and carcass of lambs, 201
Catalase in semen, 6
Cellulolytic factor
  In silage extracts, 110
Cellulose digestibility
  Cation-fat effect on, 122
  Effect of ball-milling on, 109
  Effect of minerals on, 96
  Effect of starch on, 137
  Factors affecting, of roughage, 237
Cervicovaginal mucus of sheep, 269
Chlortetracycline
  Continuous feeding of, to cows, 182
  In shipping studies with cattle, 149
Cobalt bullets in cattle rations, 191

Complementary milk
Relation of, to production, 13
Concentrate and roughage
Fed to lambs at varying times, 186
Copper
Effect on baby pig, 95
Utilization by baby pig, 214
Corn
Effect of drying temperature on, 192
Corn and alfalfa-brome silage
Substitution values for, for steers, 258
Corn, shelled
Low *vs* high moisture, for steers, 177
Corn silage
Feeding hay with, to cattle, 145
Feeding value of treated, 142
Versus sorghum silage for cows, 245
Corn-urea diet
Feeding, with and without roughage, 223
Cortisone
Effect of, on lamb performance, 112
Cotton seed
Fed whole, to beef steers, 184
In lamb rations, 115
Roughage and, mixture for calves, 234
Creep feeding
Rations for, lambs, 102
Crooked calves
Effect of nutrition on incidence of, 113
Crossbred pigs
Performance of, 28
Sired by inbred and hybrid boars, 24
Crossbreeding, cattle
Effect on reproductive performance, 33

D

Digestibility of nutrients
Comparative, by cattle and sheep, 226
Effect of minerals and fat on, 107
Digestion
Whole grain escaping, in cattle, 99
Dihydrotachysterol
Mineral levels associated with, 141
Diminishing increment
Curve of, in swine nutrition, 130
Dwarf cattle
Mucopolysaccharidosis in, 14

E

Early- *vs* late-weaned lambs, 227
Early weaning of lambs, 235
Electronically computed ration
For early-weaned pigs, 105
Energy
Digestibility of high, rations, 139
Effect of, in steer rations, 119
Effect of, intake in ewes, 224
Effect of level, on swine, 108
Effect of, on nitrate poisoning, 117
Response of lambs to levels of, 189
Ensiling unwilted forage in plastic, 259
Environmental temperature
Effect of, on thyroid secretion, 264
Reproduction as affected by, 263
Enzymes
Antemortem injection of, 54
Effect of, on digestion by wethers, 124
For fattening steers, 164
Response of lambs to, 189
Value of, for cattle, 216
Value of, for lambs, 209
Estradiol-testosterone implant
Effect on heifers, 90
Estrogenic activity
Effect of, in alfalfa on lambs, 170
Estrus, ovulation and fertility
In gilts given 6-methyl-17-acetoxyprogesterone, 306

F

Fecal flora
Effect of chemotherapeutics, 140
Feed additives
Effect of, on lamb response, 213
Feed efficiency in beef cattle, 21
Fertility of artificially inseminated gilts, 275
Fission products in Nevada range cattle, 87
Floor space allocation for swine, 222
Fluoride
Effect of age on metabolism of, 97
Effect of, on cellulose digestion, 96
Follicular growth
Influence of 6-methyl-17-acetoxyprogesterone, 307
Forage digestibility
Relationship of, to fermentation, 250
Frequency of feeding
Influence of, on range cattle, 157

G

Genetic factors
Contributing to weaning weights of calves, 9
Genetic influence
On winter gains of calves, 246
Goitrogens
Activity of several, in rat, 312

Gonadotrophin activity of swine pituitaries, 280
Gossypol
Determination of, in liver, 101
Grain preference by creep-fed calves, 156
Growth patterns
Of wether lambs, 7

H

Hams
Carcass measurement and organoleptic quality, 52
Gamma ray measurements and lean, 59
Hemorrhagic dysentery
Arsanilic acid for, in swine, 203
Hereford steers
Shade-of-red, grade and gain, 35
Heritability
Of liver and plasma vitamin A, 5
Of milk lamb gains, 11
High frequency sound
Estimation of loin eye area by, 74
Hormone
And mammary gland growth, 304
Influence of adrenal and gonadal, on gain, 267
Measuring growth, in blood, 327
Ovarian, on reproductive activity, 277
Thyroid and lactogenic, secretion, 282
Response of lambs to, implants, 174, 189
Hygromycin B
Effects on reproductive ability, 302
Hypovitaminosis A in pigs, 163

I

Immunization of sows
Effect of, on baby pigs, 265
Inbred lines and line crosses
In laboratory rat, 23
Iron
Oral, requirement of pig, 178
Requirement and effect of B-vitamins, 204
Iron-dextran
Effects of, on lambs, 133
Placental and mammary transfer, 183

K

Ketosis treatment in bovine, 270

L

Lactation
Hormone secretion during declining, 282
Lactation records
Regression factors for extending part, 32
Lamb production
Effect of early environment on, 2
Of selected and unselected ewes, 8
Light and normal weight hogs
Carcass, costs and acceptance, 49
Lignin
Excretion by cattle, 114
Loin eye area
Estimation by high frequency sound, 74
Subjective evaluation of, in hogs, 9
Longissimus dorsi
Myometric study of in bovine, 69
Low-roughage rations
Feed efficiencies of ruminants fed, 146
Lysine
Effect in cottonseed meal rations, 80
Effects on muscle and blood in swine, 41
Supplementation of milo rations, 135
Supplementation of ration for pigs, 127
Value of, in urea rations, 120

M

Manganese excess and steer performance, 194
Marbling
Quantitative determination of, 45
Maternal traits
Genetic and lactational influence, 36
Meatiness and quality in beef
Live animal and carcass measurements as indicators, 37
Meat stability
Influence of muscle firmness on, 39
Methionine
Value of, in urea rations, 120
Milk production
Biases in estimating repeatability of, 34
Milk replacer
Calves fed, mechanically, 172
Response of calves to, with fat, 218
Molybdenum
As component of "alfalfa ash factors", 116
Muscular dystrophy
Effect of ration on development, 202
Incidence of, in lambs, 132
Neurological investigation of, 325
S-amino acids, Se and antioxidant, 273
Myoglobin, nitric oxide
Photo-oxidation of, 38

N

Nitrate
Effect of dietary, on swine, 212
Effect of ingestion by lambs, 205
Effect of, in hays, 247
Levels in serum, 278
Nitrates and nitrites
Effect of, on forage digestibility, 233
Nitrite-containing rations
In vitamin A and E deficiencies, 168
Nitrogen-fertilized forages
Evaluation of *in vitro*, 236
Nutritive value index
Prediction of, by *in vitro* method, 232
Use of, and forage evaluation, 243

O

Ova transfer technique
Implantation and embryonic survival, 283
Ovulation and implantation
In swine as affected by protein, 78
Ovulation rate of Angora does, 27

P

Palatability of lamb rations, 252
Pancreatic islet changes, sheep
In response to infused glucose, 318
Pancreatic secretion in baby pig, 311
Parameters of growth
Estimates of, in heifers, 30
Pasture mixes for cattle, 230
Pasture
For replacement heifers, 244
Perennial, studies with lambs, 238
Performance of steers on irrigated, 233a
Pastures and grazing methods for lambs, 231
Pearl millet silage
Effects of additives on, 257
Pectic substances in forages, 248
Pelleted mixed hay, 143
Pelleted rations
DE and DP in, for lambs, 91
Digestibility and food passage rate in pigs fed, 196
Effect of, for lambs, 154
Effect of, on sheep, 129
Effect of, on milo utilization, 155
Growth and efficiency in pigs fed, 197
Lamb performance on high concentrate, 190
Pelleted *vs* non-pelleted creep feed, 228
Phosphatase activity
Reproductive stage on, in endometrium, 279
Phosphorus
Availability of, for calves, 219
Levels and ratios for swine, 103
Phytic acid
And growth factor response in swine, 180
Pork
Sensory attributes of, 64
Pork composition
Effect of electric shock treatment, 60
Pork loins
Intramuscular fat distribution, 42
Pork muscle characteristics
Relationship of glucose tolerance to, 61
Potassium^{40}
Use of, to determine carcass composition, 56
Potato pulp, dried
Effect of feeding, to bulls, 93
Potentiation of oxytetracycline
By alteration of Ca source, 299
Pregnancy
Maintenance of, in ovariectomized cattle, 286
Pregnancy loss, early, in sheep, 260
Preparation of whole organs, 266
Prodox (17-acetoxyprogesterone)
Effect on pregnant gilts and sows, 305, 306
Production of Hereford cows
Protein and phosphorus supplements, 254
Production-tested cattle
In feeding experiments, 26
Sale price of beef bulls, 29
Progestational agents
Estrous cycle regulation by, 284
Progesterone
Effect on estrous cycle and pituitary, 316
Levels of, in pregnant sows, 210
Variation in, of corpus luteum, 297
Progesterone-4-C^{14} to testosterone-C^{14}
Conversion of, in bovine ovaries, 294
Progestins
Influence of on estrus and ovulation, 271

Protein
Effect of, intake in ewes, 224
Effect of, on glycogen of tissues, 200
Effect of intake on blood and muscle, 169
Ovulation and implantation as affected by dietary, 78
Required by ewes on corn silage, 240
Response of lambs to, levels, 189
Utilization of, by baby pig, 187
Protein: energy ratio
Effect of, on lambs, 171
For barrows and gilts, 162
Relationship in rations of pigs, 198
Protein feeds
Value of soluble nitrogen in, 148
Purified diet
Gains of sheep fed, 173

R

Ram progeny evaluation, I, 47
Rancidity determination in pork fat, 67
Ration evaluation systems, ovine, 220
Reproductive performance of heifers
As affected by high temperatures, 263
Reproductive system
Effect of hypothalamic lipids on, 314
Restricted time grazing of dry ewes, 239
Rumen
Effect of ration form on, 106
Rumen fermentation end-products
Relation to forage feeding value, 251
Rumen fluid
Amino acid composition of, 83
Proteolytic activity of, 89
Rumen ingesta
Lipolysis by, 131
Rumen microorganisms
Amino acid metabolism, 147
Metabolism of pectic substances by, 248
Starch fermentation by, 161
Ruminal volatile fatty acids, 188

S

Selection
Early, of beef calves, 17
Carcass traits used in beef program, 16
Teaching principles of, with computer aid, 12
Semen
Catalase content, 6
Ram, collected by electro-ejaculation, 332
Sire evaluation
Owner sampler records in, 20
Sodium citrate, effect on lambs, 175
Soya protein
Predigested for baby pigs, 100
Utilization by young pigs, 150
Soybean hulls
Digestibility of, by steers, 118
Soybean meal, unextracted for swine, 166
Sources of error
Removing, in steer experiments, 158
Sperm
Bovine, diluted with antisera, 303
Effects of underfeeding on, production, 328
Influence of collection frequency on, number, 4
Triiodothyronine on output of, 281
Spermatozoan livability
Effect of CO_2 and HCO_3, 261
Spiramycin for swine, 104
Stage of maturity of forage
Changes in nutritive value due to, 229
Starch digestion
Effect of heating on, 195
Steroidal sapogenin
Value of, in fattening rations, 199
Stilbestrol
Digestible energy in ration containing, 158
Effects in suckling lambs, 285
For fattening steers, 164
Implantation of early-weaned lambs, 228
Influence on blood and muscle, 169
Influence on lamb gain and carcass, 201
Metabolism of C^{14}-labeled in rat, 293
Response to, by calves, 156
Response to, by Zebu steers, 249
Stress, transportation of gilts
Effect on fetal mortality, 309
Sugar in baby pig diets, 126
Swine repopulations, practical considerations, 319
Swine self-feeders, 134
Systems of managing ewes and lambs, 242

T

Tallow addition to swine rations, 211
Tankage
Effect on growth and carcass, 92
Temperature
Effect on pigs, 295
Effect on rabbit testis, 274
Influence on responses of heifers, 300
Rumen, rectal and skin, of sheep, 308

Tenderness
Chew count as measurement of, 51
Effect of enzyme injection antemortem, 54
Shear force and panel scores for, 46
Tenderness and meatiness
Relationship of fiber diameter to, 70
Thyroidectomies
Surgical and radioiodine, 326
Thyroid secretion
Effect of light and T on, 288
Rates of dairy cows, 313
Thyroxine
Absorption from skin in cattle, 315
And testosterone for lambs, 152
Thyroxine^{131} degradation
Temperature-humidity effects, 290
Tomato pulp
As feed for steers and lambs, 79
Tranquilizer
Digestible energy in ration containing, 158
Tylosin
A new antibiotic, 138
For swine, 104

U

Ultrasonic measurements of fatness in swine, 31
Urea
Biological evaluation of, with wethers, 123
Metabolism in sheep, 85
Urinary calculi
Effect of minerals on incidence of, 185
Sorghum grain and, in steers, 193
Uterus, sheep
Variation in inflammatory response and bactericidal activity, 287

V

Vaginal epithelium, bovine
Histological and cytological changes in, 298
Vitamin A
Effect on antibody production, 128
Levels for beef steers, 176
Vitamin A and carotene
Heritability of, in liver and plasma, 5
Vitamin E metabolism, 136
Vitamins
Role of, in ration for gilts, 208
Volatile fatty acid
Production in cattle, 217

W

Weaning
Effect of early, on lambs, 3
Weaning weights
Factors contributing to, of calves, 9
Factors influencing, of calves, 18
Genetic analysis of, of rabbits, 25
Sex and sire influence on, 22
Weight, 120- and 240-day
Factors influencing, of calves, 19
Winter feeding levels
Beef heifers on widely different, 179
Wool characteristics
Influenced by adrenals and gonads, 324
Wool production
Effect of early environment on, 2
Of range ewes of three breeds, 15
Of selected and unselected ewes, 8

X

X-irradiation
Sperm number in boar after, 4

Z

Zinc availability
Effects of phytic acid on, 167

AUTHOR INDEX FOR ABSTRACTS OF PAPERS AT THE ANNUAL NATIONAL MEETING

Note: Abstracts are referred to by number

A

Adams, C. R., 78
Aguirre, A., 80
Ahrenhold, J. E., 306, 307
Alaupovic, Petar, 136
Alexander, E. A., 159
Alexander, R. A., 226
Allen, R. S., 131, 248
Alliston, C. W., 260
Alsmeyer, R. H., 54, 200
Ammerman, C. B., 79
Anderson, David E., 1
Anderson, E. C., 56
Andrews, F. N., 201
Anggorodi, R., 121
Anthony, W. B., 234
Appel, P. P., 299
Arrington, L. R., 79

B

Backus, W. R., 37
Bailey, Milton E., 38, 65
Baird, D. M., 19, 227, 228
Baker, F. H., 122, 123
Baker, J. P., 81
Baltzer, B. V., 159
Barnhart, C. E., 82
Barrick, E. R., 101, 223
Bartlett, F. D., Jr., 261
Bateman, George, 233a
Baumgardner, J. H., 184
Baumgardt, B. R., 229, 245
Baumstark, J. S., 83
Becker, Clarence F., 241
Becker, D. E., 81, 111, 135, 166, 212, 78
Becker, R. B., 257
Badrak, Eliezer, 200
Beeson, W. M., 98, 104, 120, 133, 176, 177, 178, 180, 201, 204
Bell, D. S., 269
Bell, M. C., 84, 94, 122
Bennett, Douglas D., 21
Berry, R. K., 84, 94
Betteridge, K. J., 262
Bickoff, E. M., 170
Birmingham, Eugene, 39
Bischoff, W. B., 249
Bizzell, W. E., 227
Bland, B. J., 55
Blaser, R. E., 231
Bloomfield, R. A., 83, 85
Blumer, T. N., 223
Boda, James M., 318
Boenker, D. E., 86
Bogart, Ralph, 22
Bohman, V. R., 87
Bolin, D. W., 88
Bond, J., 263, 300
Borchers, Raymond, 89
Boren, F. W., 90, 191, 192
Boulware, R. F., 62, 211
Bradford, G. E., 2
Bradley, N. W., 73
Bratton, R. W., 281
Bratzler, L. J., 16
Bray, R. W., 42, 45, 61, 169
Brent, B. E., 91
Briggs, J. R., 268
Brinsfield, T. H., 286
Briskey, E. J., 42, 61
Brooks, C. C., 92, 41
Brooks, Jerry R., 264
Brothers, Don G., 3, 11
Brown, C. J., 52, 60
Brown, Herbert, 265
Brown, Paul B., 211
Brugman, H. H., 93
Bruner, W. H., 71
Buchanan, M. L., 88
Buck, Frank, 230
Buescher, R. G., 84, 94
Bunch, R. J., 95
Burroughs, Wise, 96, 99, 68, 148, 188, 209, 327
Butcher, G. A., 175

C

Cahilly, G. M., 41
Campbell, B. M., 106
Carpenter, J. W., 54, 200
Carpenter, Z. L., 42
Carter, R. C., 17, 154, 231
Caruolo, E. V., 266
Casady, R. B., 25
Casida, L. E., 297, 303
Catron, D. V., 100, 126, 140, 164, 225
Chamberlain, C. C., 96, 97
Chance, R. E., 98
Chapman, Arthur B., 15
Christiansen, W. C., 99
Ciordia, H., 227
Clanton, D. C., 152
Clark, A. J., 100
Clark, Burr, 250
Clark, John, 112
Clawson, A. J., 101
Clegg, M. T., 267, 324
Clifton, C. M., 160
Cline, J. H., 102, 213
Cole, J. W., 43, 44
Combs, G. E., 80, 103
Comstock, R. E., 13, 24
Connor, N. D., 270
Conrad, J. H., 104, 180
Cook, C. F., 45
Cook, M. K., 146
Cope, D. D., 177
Copenhaver, J. S., 231
Cornell, C. N., 278
Cover, Sylvia, 46
Cox, D. F., 4
Crampton, E. W., 105, 232, 243
Crookshank, H. R., 193
Cullison, A. E., 106
Cupps, Perry T., 268
Curry, W. A., 263

D

Daniel, D. L., 269
Daugherty, F. C., 236
Davidson, J. L., 270
Davis, G. K., 79, 200, 257
Davis, J. W., 41

Davis, R. E., 114
Davis, W. F., Jr., 322
Davison, Kenneth L., 107
Davison, M. E., 144
Day, W., 74
Dean, B. T., 108
Deans, R. J., 16, 47
Dehority, Burk A., 109, 137, 161, 163
Dew, Milo L., 233a
Dickey, H. C., 93
Dinkel, C. A., 18
Dinusson, W. E., 88
Diven, R. H., 5
Dollahon, J. C., 29, 37
Donefer, E., 232, 243
Donker, J. D., 13
Donoho, A. L., 110
Dudley, W. A., 111
Dunbar, R. S., Jr., 182
Durham, Ralph M., 58, 115, 184
Dyer, I. A., 112, 113
Dziuk, P. J., 271

E

Elam, C. J., 114
Elliott, Henry, 58, 115
Elliott, K. C., 134
Ellis, W. C., 116, 220
Embry, L. B., 117, 149
Emerick, R. J., 117
Emery, R. S., 147
Enfield, Frank, 24
England, Milton W., 185
Ensminger, M. E., 21, 113, 283, 309
Epley, R. H., Jr., 43
Erb, Ralph E., 310
Erek, Zuhal, 168
Erickson, D. O., 88
Erwin, E. S., 5, 119, 162, 273, 325
Ewing, L. L., 274, 328

F

Fakhrnea, B., 332
Farmer, G. R., 87
Feinstein, L., 59
Fergus, E. N., 230
Field, Ray A., 49
First, N. L., 275, 306
Flynn, Laura, 168
Fontenot, J. P., 154
Foote, R. H., 6, 281
Foote, W. C., 7, 57
Foote, W. D., 277
Fordham, J. R., 175
Fowler, M. E., 268
Fox, C. W., 170
Frame, Richard W., 38
Free, S. M., Jr., 26
Fritz, G. R., 328
Frost, D. V., 203
Furukawa, Clifton T., 308

G

Gaddy, C. D., 233
Gaines, J. A., 30
Galgan, M. W., 112
Garner, G. B., 83, 85, 110, 168, 278
Garrett, W. N., 158
Garrigus, R. R., 118
Garrigus, U. S., 205, 285
Garrigus, W. P., 230
Gawienowski, A. M., 293, 294
Gay, Nelson, 285
Gessert, R. A., 270
Gier, H. T., 298
Golumbic, C., 59
Goode, L., 279, 280
Gordon, R. S., 119, 162, 273
Gorman, John A., 8
Gossett, W. H., 120
Graham, P. P., 41
Grainger, R. B., 84, 67, 121, 122, 123, 124
Gray, L. C., 281
Griffin, S. A., 125
Grinstead, L. E., 126
Grossie, J. A., 312
Grosvenor, Clark E., 282
Guenther, J. J., 50
Guillot, Edmond, 62

H

Hafez, E. S., 283
Hale, Fred, 127
Hale, W. H., 199
Hall, O. Glen, 233
Hallett, D. K., 63
Hamann, H. K., 9
Hansard, Sam, 97, 194, 210, 211
Hansel, W., 284
Harbaugh, F. G., 58
Harmon, B. G., 128
Harrington, G., 10, 51
Harrington, R. B., 11
Harris, G. A., 113
Harris, Lorin E., 233a
Harris, R. R., 234
Harshbarger, K. E., 141
Hartman, P. H., 329
Harvey, A. L., 144, 145, 156
Hatfield, E. E., 205, 285
Haught, J. E., 129
Hauser, E. R., 169
Hawk, H. W., 286, 287
Hays, V. W., 95, 100, 126, 140, 187, 225, 295, 311
Hazel, L. N., 31, 69
Hazen, T. E., 295
Headley, V. E., 130
Heady, Earl O., 258
Heck, M. C., 52, 60
Hedrick, H. B., 53
Heidhues, T., 12
Henderson, C. R., 12, 20, 32
Henderson, H. O., 182
Henneman, H. A., 47, 288
Henricks, D. M., 104
Henrickson, R. L., 50, 70
Hentges, J. F., 14, 226
Hill, D. L., 259
Hill, F. D., 131
Hinds, F. C., 235, 242
Hiner, R. L., 59
Hobbs, C. S., 97, 233
Hodges, E. M., 246
Hoefer, J. A., 128, 130, 159, 195, 196, 197, 214, 251, 275, 306
Hoekstra, W. G., 61, 169, 215
Hoersch, T. M., 288
Hogue, D. E., 132
Holland, L. A., 35
Holleman, R. G., 171
Holper, J. C., 203
Holz, R. C., 133, 176
Hopkins, L. L., Jr., 236
Horn, L. H., 171
Horvath, D. J., 134
Hostetler, Robert L., 46
Huffman, D. L., 54
Hunt, W. L., 283
Hunter, J. E., 277

J

Jacobson, N. L., 131, 248, 329
Jahn, J. R., 237
Jensen, A. H., 81, 111, 135, 166, 212, 78
Johns, D. M., 194
Johnson, B. Connor, 136
Johnson, H. D., 290
Johnson, R. M., Jr., 71
Johnson, Ronald R., 109, 137, 142, 143, 161
Jones, J. D., 187, 311
Jones, J. H., 157
Jordan, C. E., 138, 302
Jordan, Herbert N., 139
Jordan, R. M., 238, 239, 256
Judy, J. K., 102, 213
Jung, G. A., 250

K

Kamstra, L. D., 237
Karr, Melvin R., 240, 252, 253
Kashyap, Tapeshwar S., 13
Kassir, S. M., 329
Kauffman, W. R., 59
Kelley, R. F., 92, 41
Kellogg, T. F., 140
Kemp, James D., 49, 67, 72, 73
Kendall, K. A., 141
Kercher, C. J., 174, 241
Kibler, H. H., 290
Kiggins, E. M., 203
Kincaid, C. M., 30
King, G. T., 55
Kirk, W. G., 200, 246
Kirton, A. H., 56
Kline, E. A., 68, 69
Klosterman, Earle W., 142, 143
Knight, Arlin D., 7, 57
Knoche, H. W., 293
Knodt, C. B., 222
Koch, B. A., 90, 153, 191, 192
Kodras, R., 326
Koger, M., 14, 103
Koger, Tom, 58
Kolari, O. E., 144, 145, 156
Kowalczyk, T., 61
Kraemer, D. C., 321, 322
Krueger, C. R., 245
Kulwich, R., 59
Kunkle, L. E., 71

L

Lance, R. D., 245
Lassiter, J. W., 146
Lawlor, M. J., 204
Lee, S. L., 294
Legates, J. E., 36
Lewis, J. K., 149
Lewis, J. M., 235, 242
Lewis, P. K., Jr., 60
Lewis, T. R., 147
Lindley, C. E., 29
Little, Oran, 148
Lloyd, L. E., 105, 232, 243
Lofgreen, G. P., 158
Loggins, P. E., 79
Long, R. A., 146
Loosli, J. K., 150, 183, 218
Lorincz, A. E., 14
Lowrey, R. S., 183
Luecke, R. W., 159, 195, 214, 251
Lundquist, N. S., 259
Luther, H. G., 199
Luther, R. M., 149
Lyman, Carl M., 127

M

Machlin, L. J., 273
Madsen, Milton A., 15
Magee, W. T., 10, 16, 23
Malven, P. V., 284
Maner, J. H., 150, 183
Mangold, D. W., 295
Mansfield, M. E., 235, 242
Mares, S. E., 297
Marion, G. B., 294, 298
Martin, C. M., 299
Matrone, G., 223
Matsushima, J. K., 152
Matthews, Darrell H., 7, 57
Mauger, R. E., 328
Means, T. M., 138, 302
Meiske, J. C., 145, 156
Melampy, R. M., 316, 327
Melton, A. A., 157
Menge, A. C., 303
Menzies, C. S., 91
Mertz, E. T., 98
Mestanza, W. M., 154
Meyer, J. A., 61
Meyer, J. H., 158
Meyerhoeffer, D. C., 17
Miller, E. E., 45
Miller, E. R., 128, 130, 159, 196, 197, 214
Miller, H. W., 82
Miller, W. J., 160
Minyard, J. A., 18
Miskimins, Wilson P., 241
Mitchell, G. E., Jr., 118
Mixner, J. P., 313
Mohler, M. T., 120
Moody, W. G., 74, 75, 76
Moon, Richard C., 304
Moore, John E., 161
Moorman, R. P., 28
Morrissette, M. C., 305
Moser, H. C., 293
Mott, G. O., 249
Mowat, D. N., 105
Mowery, R. C., 115
Moxon, A. L., 142
Moyer, J. H., 278
Muhrer, M. E., 83, 85, 110, 167, 168, 278
Mukhtar, A. S., 152
Mulholland, R., 162
Mullins, A. M., 62, 211
Murphey, C. E., 63
McCaleb, J. E., 246
McCall, J. T., 79, 226, 257
McCampbell, H. C., 227, 228
McCartor, M. M., 153
McClaugherty, F. S., 154, 231
McClure, W. H., 154
McCroskey, J. E., 155
McCullough, M. E., 244
McDaniel, B. T., 300
McDonald, L. E., 305
McDowell, R. E., 263, 300
McGilliard, A. D., 329
McLaren, G. A., 182
McLaren, J. B., 28

N

Naumann, H. D., 39, 53, 64, 65, 74, 75, 76
Neagle, L. H., 100
Neff, A. W., 270
Neill, Jim, 184
Nellor, J. E., 275, 306, 307

Nelson, Eldon C., 163
Nelson, LeRoy F., 164
Nelson, R. H., 307
Neumann, A. L., 118
Neville, W. E., Jr., 19, 227
Nickelson, W. F., 166
Niedermeier, R. P., 245
Noffsinger, Terrell L., 308
Nofziger, James C., 309, 310
Norcross, M. A., 286
Norton, H. W., 78

O

Oberleas, D., 123, 167
O'Bleness, G. V., 20
O'Dell, B. L., 167, 168
Odell, G. V., 50
Odom, L. A., 44
Ogilvie, M. L., 169
Oldfield, J. E., 170
Olsen, R. H., 171
Olson, W. A., 172, 266
Oltjen, Robert, 173
O'Mary, C. C., 21
Orme, L. E., 43
Otagaki, Kenneth K., 308
Oxley, J. W., 174

P

Packett, L. V., 175
Page, H. M., 5
Pahnish, O. F., 5, 22
Palmer, A. Z., 54, 200
Parker, H. E., 180
Parker, L. S., 8
Parrish, F. C., Jr., 65
Payne, L. C., 152
Peacock, F. M., 200, 246
Pearson, A. M., 10, 16, 51, 56
Pekas, J. C., 311
Perdue, H. S., 203
Perez, C. B., Jr., 247
Perry, T. W., 120, 133, 176, 177, 201
Petersen, W. E., 13
Pfander, W. H., 86, 116, 129, 186, 220, 278
Phillips, P. H., 224
Pickett, R. A., 178
Pierce, J. C., Jr., 63
Pilkington, Dwain, H., 66
Pinney, Don, 179
Pipes, Gayle, 264, 312
Plumlee, M. P., 178, 180, 204
Polan, C. E., 182
Pond, W. G., 150, 183
Pope, A. L., 215, 224
Pope, L. S., 155, 179
Porterfield, I. D., 182
Post, T. B., 313
Poston, H. A., 314
Pounden, William D., 163
Powell, Dallas, 184
Pratt, David R., 23, 185
Premachandra, B. N., 315
Pressey, R., 248
Preston, R. L., 186
Priode, B. M., 17
Puchal, F., 187

Q

Quinn, L. R., 249
Quinn, L. Y., 140, 327

R

Raeside, J. I., 262
Ragsdale, A. C., 290
Ramsey, C. B., 44
Rapp, Janet L. C., 185
Raun, Ned S., 188
Ray, D. E., 316
Rea, John C., 189
Reber, E. F., 326
Reid, R. L., 250
Reineke, E. P., 288
Rempel, W. E., 24
Reynolds, W. M., 199, 299
Rhodes, Robert W., 190
Rhodes, V. J., 64
Rice, R. W., 251
Richardson, D., 90, 91, 191, 192, 216, 217
Ricketts, Gary E., 143
Riggs, J. K., 157, 193
Riley, Perry W., 318
Ritchie, H. D., 214
Robertson, G. L., 62, 194
Robertson, J. C., 82
Robinson, N. W., 194
Rollins, W. C., 25
Ross, C. V., 189, 240, 252, 253, 264
Roubicek, C. B., 5, 22

S

Salsbury, R. L., 195, 251
Sanger, Vance L., 163, 269
Santolucito, J. A., 314
Saylor, J. H., 131
Schales, Nina, 6
Scheidy, S. F., 26
Schmidt, D. A., 159, 214
School, J. M., 258
Schuch, R. L., 56
Scott, G. C., 26
Scott, Harold W., 142
Seerley, R. W., 196, 197
Sell, O. E., 19, 227, 228, 244
Sewell, R. F., 198
Seymour, W. R., 59
el-Shazly, K., 137
Sheff, A., 325
Sheffy, Ben E., 319
Shellenberger, P. R., 329
Shelton, D. C., 250
Shelton, Maurice, 27
Sherman, W. C., 199, 299
Shirley, R. L., 200
Simms, R. H., 201
Sirny, Robert, 173
Sisk, L. R., 244
Skinner, Philip E., 1
Skipitaris, C. N., 202
Smith, Dale, 229
Smith, E. F., 35, 90, 191, 192
Smith, F. H., 101
Smith, H. J., 28
Smith, I. D., 203
Smith, S. E., 219
Smith, W. H., 9, 178, 180, 204
Sokolswski, J. H., 205
Sorensen, A. M., Jr., 322
Speer, V. C., 95, 100, 126, 140, 187, 225, 295, 311
Spurlock, G. M., 267, 324
Staheli, D. L., 171
Stanley, E. B., 22
Starling, J. G., 234
St. Clair, L. E., 326
Stephens, D. F., 155, 179
Sterner, W., 273, 325
Stonaker, H. H., 28a
Stone, W. H., 303
Stormshak, Fred, 310
Story, C. D., 236, 247
Stringer, William C., 38

Stromlund, E. V., 326
Stroud, J. W., 121, 122, 123, 124
Summers, C. E., 68
Swanson, L. A., 69
Swierstra, E. E., 281
Sykes, J. F., 286, 287
Synhorst, S. H., 248

T

Taylor, J. C., 29, 37
Teague, Howard S., 163, 207, 208
Templeton, W. E., 230
Terrill, S. W., 81, 111, 135, 166, 212, 78
Theurer, Brent, 209
Thomas, H. R., 92
Thomas, M. C., 198
Thomas, O. O., 254
Thompson, A. M., 311
Thompson, G. B., 129
Thompson, O. A., 214
Thompson, R. C., 174
Thornton, J. W., 30
Thrasher, D. M., 62, 210, 211
Tillman, Allen D., 173
Todd, A. C., 215
Todd, A. S., 332
Tollett, J. T., 212
Torell, D. T., 2
Touchberry, Robert W., 33
Traeder, D. H., 42
Travis, H. G., 29, 37
Trenkle, Allen, 327
Tribble, L. F., 86, 108, 76
Tsien, W. S., 91, 191, 192, 216, 217
Tuma, H. J., 70
Tureen, L., 273, 325
Turk, R. M., 268
Turner, C. W., 312, 315
Turner, G. D., 286, 287
Tyler, W. E., 63
Tyler, W. J., 303
Tyznik, W. J., 102, 213

U

Ulberg, L. C., 260, 314
Ullrey, D. E., 128, 159, 214
Urban, W. E., 31

V

VanDemark, N. L., 261, 274, 328
Vandepopuliere, J. M., 103
Van Dilla, M. A., 87
Van Dyne, G. M., 254
Van Horn, H. H., Jr., 329
VanStavern, B. D., 71
VanStavern, Jack, 142
VanVleck, L. D., 32
Varney, W. Y., 49, 72, 73
Venable, J. H., 50, 70
Verley, Frank A., 33
Vetter, R. L., 215
Voigt, V. T., 6
Volk, J. D., 64

W

Wade, M. A., 87
Wadell, L. H., 20, 34
Waitt, W. P., 138, 302
Walker, R. W., 106
Wallace, H. D., 80, 103, 279, 280
Waller, George, 155
Walters, Lowell E., 66
Ward, C. Y., 231
Ward, Gerald M., 139
Ward, J. K., 191, 192, 216, 217
Warner, R. G., 132, 218
Warnick, A. C., 14, 200, 279, 280
Warren, E. P., 146, 332
Warwick, E. J., 263, 300
Wearden, S., 9, 90
Wedin, W. F., 238, 239, 256
Weeth, H. J., 277
Weir, W. C., 2
Welch, J. A., 250
Wentworth, R. A., 219
Whatley, J. A., 305
Wheat, J. D., 35
Whetzal, F. W., 149
Whitaker, D. R., 180
White, J. W., 146
White, T. W., 220
Whiteman, J. V., 3, 11, 66
Whitmore, G. E., 286
Wilcox, C. J., 257
Willham, R. L., 4
Williams, G. C., 37
Williams, J. B., 172
Willson, F. S., 254
Wing, J. M., 257
Wingert, F. C., 222
Wise, M. B., 219, 223
Woods, Walter, 107, 68, 190, 209, 258
Wright, P. L., 224
Wuthier, P. R., 70

Y

Yoder, J. M., 259
Young, C. W., 36

Z

Zimmerman, D. R., 225
Zobrisky, S. E., 74, 75, 76
Zutaut, C. L., 159, 214

NEWS AND NOTES

Meeting of the American Society of Animal Production. The 52nd annual meeting will be held at the Hotel Sherman, Chicago, Friday and Saturday, November 25 and 26, 1960. Registration is at 8:00 a.m. Friday. Sectional meetings that day will be held from 9:30–11:00 a.m. and a general session at 11:00 a.m.–12:00. Sectional meetings will continue Friday afternoon 1:00–4:00 p.m. and on Saturday, 9:00 a.m.–12:00; 1:00–4:00 p.m. and, 7:30–9:30. The annual dinner and presentation of awards will be held on Friday, 6:00 p.m. and will be followed by the annual business meeting.

The Nominating Committee of the American Society of Animal Production has recommended for presentation at the annual business meeting the following candidates for office: For President, H. H. Stonaker, Colorado State University; and, for Vice-president, T. J. Cunha, University of Florida and C. S. Hobbs, University of Tennessee. The term of office of the present Secretary-Treasurer, C. E. Terrill, Agricultural Research Center, USDA does not expire until 1963.

The Western Section of the Society at its annual meeting in June elected the following officers: O. F. Pahnish, President, University of Arizona, Tucson; James A. Bennett, Vice President, Utah State University, Logan; and, T. Donald Bell, Secretary-Treasurer, University of Idaho, Moscow. The 1961 meeting will be held on the University of Idaho campus July 16, 17 and 18, 1961.

The North Atlantic Section of the Society at its annual meeting at Amherst, Massachusetts elected the following officers: President, W. A. Cowan, University of Connecticut; Vice-President, George W. Vander Noot, Rutgers University; and Secretary-Treasurer, John Bratzler, Pennsylvania State University. The North Atlantic Section meeting for 1961 will be held August 22–23 at the Pennsylvania State University.

Techniques and Procedures in Animal Production Research. A Monograph in the process of publication by the American Society of Animal Production. The Monograph is composed of the following sections: Design and Analysis of Animal Husbandry Experiments by C. R. Henderson; Techniques for Research in Quantitative Animal Genetics by Gordon E. Dickerson; Research Techniques in Physiology of Reproduction in the Female by L. E. Casida; Design for Comparative Feeding Trials by E. W. Crampton; Methods Employed in Nutrition Research by Ivan L. Lindahl; Meat Research Techniques Pertinent to Animal Production Research by O. G. Hankins, A. M. Gaddis and W. L. Sulzbacher. One copy will be supplied free to each member of the Society. Other persons, including subscribers, may order copies at $4.00 each to the U. S. and Canada, and $5.25 each to other countries from C. E. Terrill, Animal Husbandry Research Division, Agricultural Research Center, Beltsville, Maryland. Copies should be ready to mail soon.

Information to Contributors. Some slight changes have been made in the material on the back cover of the Journal.

The Division of Biological and Medical Sciences of the National Science Foundation announces that the next closing date for receipt of basic research proposals in the Life Sciences is January 15, 1961. Proposals received prior to that date will be reviewed at the spring meetings of the Foundation's advisory panels and disposition will be made approximately four months following the closing date. Proposals received after the January 15, 1961 closing date will be reviewed following the summer closing date of May 15, 1961. The next closing date for submission of proposals for specialized biological facilities is March 1, 1961. The NSF has two programs for support of facilities, one for general graduate level university laboratories and the other

for specialized biological facilities. The latter are defined as discrete research installations which are unique, one-of-a-kind, or at least less than ordinary in that they are not a usual part of a university department and may represent either new ventures or the more traditional establishments. Inquiries should be addressed to the National Science Foundation, Washington 25, D. C.

Application for Translation and Publication of Foreign Biological Material. New forms have been prepared by American Institute of Biological Sciences. Several copies have been sent to C. E. Terrill, Secretary-Treasurer, to acquaint our Society with the AIBS Translations Program and make such copies available to members for requesting translations. Additional information about the program may be obtained from Francis C. Harwood, Director of Publications, AIBS, 2000 P Street, N.W., Washington 6, D. C.

Symposium of Section O (Agriculture). AAAS. Land-Zoning in Relation to Agricultural, Suburban, Industrial, Forest, and Recreational Needs of The Future. The symposium will be held at the Biltmore Hotel, New York City, December 27–30, 1960.

The World Symposium on Genetics will be held June 13–15, 1961, at Turin, Italy. Information concerning the symposium can be secured by contacting Minerva Medica, Corso Bramante 83–85, Turin, Italy. This meeting is part of the 4th International Medical Surgical meeting.

The 8th International Congress of Animal Husbandry will be held in Hamburg, Germany, on June 12–18, 1961. For further information contact the European Association for Animal Production, via Barnaba Oriani, 28, Rome, Italy.

The 4th International Congress on Animal Reproduction will be held in The Hague, Netherlands, on June 5–9, 1961. Further information may be obtained from The Secretariat, Burgemeister de Monchyplein 14, The Hague, Netherlands.

The 10th Pacific Science Congress of the Pacific Science Association will be held at the University of Hawaii, Honolulu, from August 21 to September 6, 1961. The Congress is sponsored by the National Academy of Sciences, Washington, D. C., and Bernice P. Bishop Museum, with the cooperation of the University of Hawaii. Scientific sessions will be held from August 21 to September 2 with a post-sessional field trip through September 6. The program is being organized under Sections and Divisions. Symposia are the main divisional meetings, but provision is also being made for sessions of grouped papers and sessions of contributed papers. In addition to sectional and divisional programs, there will be a limited number of special symposia of broad general interest. The Division of Animal Science will have programs in the areas of animal nutrition and animal breeding. For further information on programs, address inquiries to Secretary General, Tenth Pacific Science Congress, Bishop Museum, Honolulu 17, Hawaii. A brochure is available from the National Academy of Sciences, Washington, D. C.

The Sixteenth International Congress of Zoology will be held in Washington, D. C., August 21–27, 1963. Further information may be obtained from Dr. Gairdner B. Moment, AAUW Building.

The Association of American Colleges and the American Association of University Professors, with the help of a grant from the Ford Foundation, has established an office at 1785 Massachusetts Ave., N.W., Washington, D. C., called the Retired Professors' Registry, under the direction of Dr. Louis D. Corcon. This registry was established in 1957 primarily to serve as a placement service for retired college and university faculty members and administrators who want to be considered for appointments in institutions other than those from which they have retired. Retirees in the biological sciences are wanted in larger numbers than can be supplied by the Registry. Society

members about to retire are encouraged to register even though they may not want or need a position at this time.

Word has been received of the untimely death of Stanley W. Terrill, Professor, Animal Science, University of Illinois.

At the University of Kentucky, George E. Mitchell, Jr., former Assistant Professor of Animal Husbandry at the University of Illinois, has accepted the position of Associate Professor of Animal Husbandry beginning September 8, 1960. C. Oran Little who completed the requirements for the doctorate in animal nutrition with a minor in biochemistry at Iowa State University in August has accepted a position as Assistant Professor of Animal Husbandy. R. B. Grainger, former Assistant Professor of Animal Husbandry has accepted a position with the Monsanto Chemical Company of St. Louis, Missouri.

Harold Barber, shepherd for the past 38 years at the University of Kentucky, passed away August 6, 1960, at Lexington, Kentucky.

At Oregon State College, A. T. Ralston joined the staff July 1 as Assistant Professor of Dairy and Animal Husbandry in charge of beef cattle. Dr. Ralston holds the B.S. degree from Montana State University and a Ph.D. from Washington State University. Hugo Krueger, Professor of Dairy and Animal Husbandry, accepted an appointment with the University of Afghanistan under contract with University of Wyoming, effective July 1. Fred F. McKenzie, Professor of Dairy and Animal Husbandry, has accepted an appointment (ICA) with the University of Indonesia on the island of Java, under contract with the University of Kentucky, effective July 1; I. R. Jones, Professor of Dairy and Animal Husbandry, will be on sabbatical leave, effective September 1. Dr. Jones will be on a Fulbright Lectureship with the University of Cork, Cork, Ireland.

Marvin Koger and Alvin C. Warnick, University of Florida, spent June of 1960 at Maracay, Venezuela, advising the Central University of Venezuela on their Animal Science program. Their trip was sponsored by the Venezuela Creole Oil Foundation and is part of a program between Venezuela and the University of Florida.

Irving I. Geshwind has been appointed Associate Professor of Animal Husbandry, University of California, Davis. He received his Ph.D. in endocrinology at the University's Berkeley Campus in 1949, and comes back to Davis from San Francisco where he has been Associate Research Endocrinologist at the Hormone Research Laboratory.

R. O. Berry resigned as Professor in the Department of Animal Husbandry at Texas A and M College effective August 31, to head a beef cattle fertility project with the Wortham Foundation of Houston, Texas. Dr. Berry received his B.S. in 1929 at North Texas State College, his M.S. at Texas A and M College in 1932, and his Doctorate at Johns Hopkins University in 1939. He has been at Texas A and M College since 1931.

Harold H. Cole, Professor of Animal Husbandry, University of California, Davis, was presented with the Order of the Golden Fleece, for exceptional service to the sheep industry, by the California Wool Growers Association during its 100th annual convention in San Francisco on September 12. After many years as chairman of the Department of Animal Husbandry at Davis, Dr. Cole returned to full-time research and teaching last July 1.

Richard H. Ross, a member of the staff since 1947, became head of the Department of Dairy Science at the University of Idaho on July 1. He succeeds D. L. Fourt, who has been department head for the past 14 years. Dr. Fourt now becomes a full-time

Professor of Dairy Science and Dairy Scientist with the AES. In recognition of 38 years of continuous service to the Idaho dairy industry, the University's board of regents promoted Fourt to Emeritus Head of the Department.

R. R. Woodward has resigned his position in charge of beef cattle research at the U. S. Range Livestock Experiment Station, Miles City, Montana to become beef cattle advisor for American Breeders Service of Chicago, Illinois.

James M. Boda, Associate Professor of Animal Husbandry, University of California, Davis, left in July for New Zealand to spend nine months in research on the bloat problem of cattle. This research is supported by a Fulbright grant and the work will be done at the Plant Chemistry Division in Palmerston North, New Zealand. Dr. Boda has been a member of the animal husbandry staff at Davis since 1952. He will return to the Davis campus in June 1961.

Boyd T. Whittle, Extension Associate Livestock Specialist in the Animal Husbandry Department, University of Maryland, for the past 12 years has resigned effective September 19, 1960, to accept a position with ICA as Livestock Advisor. He will leave about October 10 for Brazil on a two-year assignment. Extension work in beef cattle and horses will be taken over by Dr. James R. Ferguson. On September 1, Dr. Paul H. Engle took over the swine and sheep extension work formerly handled by Dr. Ferguson.

R. W. Swift, Head of Animal Nutrition, Pennsylvania State University retired on June 30. Russell C. Miller became Chairman of the New Department of Animal Industry and Nutrition on July 1, with the merging of the two departments.

E. R. Berousek formerly of Oklahoma State University became chairman of the Department of Animal and Dairy Husbandry, University of Delaware, on September 1. Dr. Berousek received his B.S. in '41 and his Ph.D. in '59 from Oklahoma State University, and his M.S. in '42 from Missouri University. He replaces J. W. Cobble who plans to devote full time as Associate Dean and Director of the Delaware station.

George K. Davis, Professor of Animal Nutrition at the Florida station, has been named Director of Nuclear Activities at the University of Florida. Dr. Davis will be lecturing during part of the months of October and November in Buenos Aires, Argentina.

Curtiss M. Bailey has been appointed Animal Geneticist in the Department of Animal Husbandry, University of Nevada, with a joint assignment in teaching and research. He will have charge of research work in animal genetics, specializing in animal breeding. Dr. Bailey received his B.S. and Ph.D. degrees from the University of Wisconsin and his M.S. degree from Texas A and M.

E. H. Vernon, Animal Husbandry Research Division, Agricultural Research Service, has accepted a two-year assignment with the International Cooperation Administration as animal husbandry research advisor in Argentina, South America. His assignment is concerned principally with beef cattle research.

Frank A. Hudson joined the Animal Husbandry staff of Texas Tech on September 15, 1960, as Assistant Professor, and will have responsibility for research and teaching in the area of sheep husbandry. Dr. Hudson recently resigned his position as Geneticist with the U. S. Department of Agriculture, Beltsville, Maryland.

W. A. Hardison, Associate Professor of Dairy Science, VPI, was awarded the American Feed Manufacturers' Award by the American Dairy Science Association at its 1960 annual meeting.

Damon C. Shelton, Professor of Biochemistry, Department of Agricultural Biochemistry, University of West Virginia, joined the staff of the Department of Biochemistry of the University of West Virginia Medical Center on September 1, 1960.

Louis J. Pierro has joined the staff of the University of Connecticut as Associate Professor of Animal Genetics. Dr. Pierro has a B.S. degree from St. Joseph's College in Philadelphia, an M.S. degree from Marquette University and a Ph.D. in Biology from Brown University.

A. L. Moxon, Associate Chairman of the Department of Animal Husbandry at the Ohio Agricultural Experiment Station, will spend six months, beginning in September 1960, as animal nutritionist advisor for the Punjab Government Agricultural College, at Ludbinana in Northwest India. Professor Moxon will also spend some time at the National Dairy Research Institute at Karnal, Punjab, to advise on nutrition research programs.

T. Scott Sutton was recently named Assistant Director of the Ohio Agricultural Experiment Station in addition to his previous duties as Associate Dean of the College of Agriculture and Home Economics, Ohio State University, and part-time member of the experiment station staff.

Fred E. Deatherage, Chairman of the Department of Agricultural Biochemistry, Ohio State University, was named to head also the counterpart Department of Agricultural Biochemistry recently established in the Ohio Agricultural Experiment Station at Wooster.

Kent Riddle has resigned his position as Assistant Animal Husbandman, Colorado Agricultural Experiment Station, located at the San Juan Basin branch station near Hesperus, to accept a position with the Codding brothers at Forakes, Oklahoma. Riddle will be in charge of a breeding cow herd of about 1500 animals used in a performance and progeny testing program.

Khaled el Shazly, of the University of Alexandria, Egypt, recently returned to his homeland after completing post-doctoral research in ruminant nutrition at the Ohio Agricultural Experiment Station.

M. Rechcigl, Jr. joined the staff of the Laboratory of Biochemistry, National Cancer Institute, National Institutes of Health, Bethesda, Maryland, as Biochemist in the Metabolism and Enzyme Section. He was a Public Health Service Research Fellow in the laboratory for two years prior to this appointment.

Diet in Relation to Reproduction and the Viability of the Young, Part III, Pigs.—Technical Communication No. 21 by D. L. Duncan and G. A. Lodge with a foreword by R. G. Baskett; 106 pages; 20 S; Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 1960. This small volume makes an impressive contribution to our literature concerning the relationship between diet and reproductive performance in swine. The authors have reviewed over 300 papers in making a most comprehensive survey of the subject. Included is a limited discussion of appropriate criteria of sow productivity and comparisons with present-day productivity. Also chapters on physiology, variations in the reproductive performance of sows and their causes, requirements of the sow, and nutrition of the boar along with an excellent bibliography are included. The literature reviewed includes many foreign citations and while indicative of a great deal of research done it seems to emphasize that there is much that we do not know about the subject. This book is replete with documented research but it may leave the reader wishing that the authors had summarized and interpreted a bit more than they did. This of course is difficult if not impossible with a subject where there is still so much to learn. Research workers will welcome this book as a very useful survey of a very difficult subject.—J. A. H.

SUBJECT INDEX FOR VOLUME 19, 1960

Note: Sectional (Southern and Western) meeting abstracts, by page, are identified by an asterisk. National meeting abstracts, by number, have a separate index at the end of that group of abstracts.

A

Abstracts
  Annual national meeting, ASAP, 1216
  Southern section, ASAP, 643
  Western section, ASAP, 956
Additives, feed, for pigs, 643*
Adrenal Glucocorticoids
  Effect of, on semen, 509
Air velocity
  Effect of, on gains of steers, 60
Alfalfa
  Effect on serum protein fractions, 970*
  Effect of grind and level on lambs, 1031
  Effect of level on swine, 887
  Estrogenic activity of, 745
  Factors affecting, hay quality, 283
  Supplementation in cattle fattening, 651*
  Supplementation of soilage or hay, 156
  Yield and digestibility of, 5
American Society of Animal Production
  A.F.M.A. award, 338
  A.S.A.P. Extension award, 341
  A.S.A.P. Teacher award, 343
  Chairman of committees, 352
  Fellows elected, 345
  Memorials, 349
  Minutes of business meeting, 323
  Morrison award, 336
  Proceedings of 51st annual meeting, 313
Amino acid excretion patterns
  Of preweaning pigs, 962*
  Of weanling pigs, 962*
Angora does
  Estrous cycling and ovulation, 368
Animal Agriculture, future of, 317
Antibiotics
  Sustained prevention of bloat by, 735
Antibiotics, oil meal and silage
  In cattle fattening rations, 1041
Antibiotic supplementation
  Effect of, on swine, 887
Arsanilic acid
  Excretion studies in swine fed, 140
  In selenium poisoning, 260
  In ration of calves, 38
Artificial rumen
  Technique for determining digestibility, 971
Artificially dried hay
  Effect of temperature on, 1186
Award
  American Feed Manufacturers' Ass'n, 338
  ASAP Extension, 341
  ASAP Teacher, 343
  Morrison, 336
  Rules governing Teacher, 309

B

Baby pig rations
  Enzyme supplementation of, 932
Bagasse
  Utilization in fattening rations, 648*
Barley
  Effect of hulls on swine carcass, 969*
  Rations for swine, 601
Beef bulls
  Factors influencing weight and grade, 651*, 657*
Beef quality
  Specific gravity as a measure of, 167
Behavior studies
  Observations in, with grazing cattle, 1204
Birth and weaning weight
  Of heifers' first calf, 956*
Birth weight
  In Angus and Shorthorns, 470
Biuret
  Utilization by lambs, 44
Black-eye peas
  As a swine feed, 164
Blackstrap molasses
  Net energy of, 392
Bloat
  Effect of alfalfa pasture, on blood, 1172
  Effect of penicillin on, 656*
  From feeding soybean oil meal, 1089
  In steers on Ladino clover, 656*
  Sustained prevention of, 735

Blood compounds
Effect of bloat on, of cattle, 1172
Blood volume
Of Brahman and Hereford cattle, 654*
Blowfly strike
Field control of, 34
Bluestem pasture
Digestibility of forage on burned, 388
Body composition
Variation in, of mice having same gain, 769
Bulky rations
Response of mice fed, 970*
Business meeting, ASAP
Summary of minutes of, 323

C

Calcium
Interrelationships between Zn, Fe, Cu and, for swine, 249
Metabolism in aging rats, 963*
Cancer eye, studies on bovine, X, 790
Carbimazole, goitrogenic activity of, 553
Carcass, beef
Effect of fattening practice on, 650*
Effect of methimazole on, 465
Effect of stilbestrol in altering, 990
Estimating protein and fat in, 1190
Influence of certain grades on, 656*
Predicting lean in mature, 726
Relationship of certain cuts and measurements to total lean in, 89
Rib cut, 12th for measuring yield, 109
Carcass characteristics
Effect of 3,3′ diallylhexestrol on, 1009
Effect of protein levels on, 943
Of 160- and 200-lb. hogs, 644*
Of steers in Gulf Coast region, 820
Carcass grade
Influence of Tapazole on steer, 645*
Of lambs under range conditions, 493
Slaughter and, in beef cattle, 722
Carcass merit
Estimation of, of swine, 1013
Swine selection indexes as indicators, 1024
Carcass, swine
Effect of protein and energy on, 67
Influence of feeding level on, 274
Cellulose
Effect of fatty acids on digestion of, 54
Effect of, on swine carcass, 969*
Cellulose digestion
In vitro and *in vivo*, 867
Chairmen of committees, 352
Chlorpromazine residue in beef tissues, 26
Chlortetracycline
For growing-finishing swine, 363
Chopping vs. grinding
Effect of, on nutritive value of hay, 859
Cooling devices
Effect of, on growing swine, 644*
Copper
Availability of, from inorganic compounds, 754
High level, for swine, 1153
Corn
Nutritive value of dried, 376, 629
Corn oil in baby pig diet, 709
Corn, relative value
Low-moisture and ensiled high-moisture, 515
Corn silages
Whole plant and ground ear, 522
Corpora lutea
Exogenous progesterone on, of gilts, 101
Corpus luteum
Effects of injected ovarian hormones, 175
Creep feeding farm flock lamb, 852
Crossbreeding
Effect of, on age at puberty, 687

D

Death losses, pre-weaning, in lambs, 616
Diallylstilbestrol
Effect of, on steer calves, 966*
Value of, for yearling steers, 966*
Diallylhexestrol
Effect of, on steer calves, 966*
Effect of, on steer and carcass, 1009
Diethylstilbestrol
Effect of, on grazing steers, 645*
Effect on utilization in lambs, 44
Response of pigs to, 646*
Differential growth of male and female calves, 956*
Digestibility
Alfalfa, 5
Corn silages, 522
Effect of fatty acids on, 54
Effect of grinding and pelleting, 652*
Influence of minerals on, 1071
Of pelleted creep feed, 648*
Relationship of feed intake and collection period to, 1150

Distinguished teacher award, rules, 309
Dwarf beef calves
  Growth hormone content of pituitary, 647*
  Grow hormone in pituitary from, 810
Dwarfism
  Bovine heart in relation to, 948

E

Embryonic mortality
  In three breeds of swine, 881
Energy
  Effect of intake on ovulation, 295
  Effect of level on protein requirement, 1049
  Effect of level on reproduction, 643*
  Effect of, supplements on lambs, 773
  Effect of varying intake on swine, 67
Enzyme
  Addition to cattle rations, 458
  Supplementation of pig rations, 932
  Value of, preparation for steers, 966*
Erratum, 357, 1215
Errors, controllable
  Effect on estimates of genetic parameters, 1208
Error, sources
  Removing in cattle feeding experiments, 1123
Esophageal fistula samples
  Diet of sheep determined by, 560
Estrogenic activity
  Effect of drying on, of alfalfa, 745
  In forages, 189
  In fresh and dried clover, 1143
Estrous cycling
  Influence of male goat on, of Angora does, 368
Estrus
  Control of, by progestational compounds, 412
Ewe selection
  Two systems of replacement, 956*

F

Face covering, angora does
  Relation to fleece, body weight and kid production, 302
Fallout I_{131} in Reno cattle, 963*
Fasting
  Effects of, on yields, shrinkage and pH, 242
Fat
  Effect of level on swine, 1115
  Effect on serum protein fractions, 970*
  Estimating in steer carcass, 1190
  Modifying tissue lipids by, 959
Fat depth
  Measuring, in lambs, 803
Fatty acids
  Effect of digestibility, 54
Feed intake level
  Reaction of pigs to, 84
Feed utilization
  Efficiency of, in beef cattle, 957*
Fellows, ASAP, 345
Fertility
  Studies of sheep, I. 959*
  Studies of sheep, II. 960*
Fleece weight
  Methods of estimating clean, 958*
  Relation to face covering, 302
Forage, irrigated
  Recovery interval in grazing, 981

G

Genetic and phenotypic parameters
  Estimates of, in beef cattle, IV. 700
Genetic parameters
  Controllable errors on estimates of, 1208
Genotype and plane of nutrition
  Interaction between, in selection for gain, 434
Gestation length
  In Angus and Shorthorns, 470
Goitrogenic activity
  Of Trapazole and Carbimazole, 553
Goitrogens
  Assay of, in feed, 1181
  Effect of, on thyroid activity, 678
Gonadotropins
  Effects of equine, on ewe, 646*
Grazing intensity
  Effect of, on performance, 649*
Grease wool
  Detergents in scouring, 958*
Growth factors
  Organic and inorganic sources of, for pig, 226

H

Ham, composition
  Radioactivity of ash in relation to, 119
Hematology
  Effect of nutrition on, of heifers, 970*

Hemoglobin
Estimation of, in muscle extract, 1164
Level of, in baby pig, 183
Level of, and weight of ewes, 653*
Heritability
Daughter-dam pairs for estimating, 916
Of 18-mo. weight of heifers, 956*
Heritability of characteristics
In record of performance bulls, 450
Hormonal control
Of reproductive activity in ewe, 607
Hormones
Effect of, implant on suckling lambs, 965*
Injected ovarian corpus luteum, 175
Ovariectomized gilt treated with gonadal, 114
Pig growth, 1002
Hydroxyzine
For steers, 965*

I

Inbreeding
Effect of, on breeding soundness, 665
Index for abstracts,
Author, National meeting, ASAP, 1346
Subject, National meeting, ASAP, 1340
Internal parasites infestation
In cattle grazing Coastal Bermuda grass, 655*
Iron
Effect of Mn on, metabolism, 655*
Methods of administration, 183
Parenteral, preparation, 763
Iron-dextran injection
Intramuscular and intraperitoneal, 484

K

Kid production, angora does
Relation to face covering, 302

L

Lamb mortality
In a western range flock, 265
Lamb racks, scoring system, 957*
Live animal measurements
Estimation of carcass merit from, 1013, 1024
Loin eye area
Relationship to lean in beef, 89
Loin eye muscle
Measurement of, by ultrasonic reflections, 786
Longissimus dorsi muscle
Measuring cross-sectional axes of, 803
Lungworm, cattle, immunity against, 655*
Lysine
Supplementation in rabbit ration, 967*

M

Manganese
Effect on iron metabolism, 655*
Meat quality, beef
Rib cut, 12th, for measuring, 109
Meat tenderness
Measuring, in live animal and carcass, 644*
New measuring device, 645*
Memorials, 349
Methimazole
Effect on fattening cattle, 465
Supplementation in rabbit ration, 967*
Milking machine for sows, 780
Milk lamb gains
Factors influencing, at 50–90 lb., 653*
Milk production
In sows, 150
Of beef Shorthorn cows, 502
Milk, yield and composition
From Brahman and Hereford cattle, 654*
Mineral metabolism
Effect of ration on, of lambs, 127
Minerals
Effect of, on pork muscle color, 1195
Influence of, on calves, 1071
Muscular dystrophy in lambs
Effect of fish liver oil, vitamin E and selenium, 620
Myoglobin
Estimation of, in muscle extracts, 1164

N

Net energy
Of blackstrap molasses, 392
News and notes, 353, 658, 972, 1351
Nitrogen metabolism in lambs, 44
Nucleic acids
Of heart and muscle of cattle, 651*
Nutritive intake levels
Response of sheep to different, 969*
Nutritive plane
Effect of, on growth and hematology of heifers, 970*
Nutritive Value Index
Effect of grinding of hays on, 859
For forages, 538
Prediction of, from *in vitro* data, 545

O

Oleandomycin
Effect of, on growing pig, 800
In lamb fattening ration, 590
Ovulation
Control of, by progestational compounds, 412
Influence of male goat on, 368
Rate as affected by energy intake, 295
Oxytetracycline
Effect of, on grazing steers, 645*
Feeding to fattening steers, 648*
For growing-finishing swine, 363

P

Pantothenic acid
Effect of level on swine, 1115
Parakeratosis in swine
Effect of autoclaved diet, 568
Serum proteins, 580
Parakeratosis, rumen
Effect of pelleting on, 652*
Pelleted creep feeds
Digestibility and value of, for calves, 648*
Pelleted rations for lambs, 968*
Pelleting
Barley rations for swine, 601
Effect of, on alfalfa hay quality, 283
Effect of, on digestibility and parakeratosis, 652*
Effect of, on hay digestibility, 873
Hay, in wintering rations for calves, 715
Penicillin
Effect of continuous, on bloat, 656*
Performance of pigs
Weaned at 3 and 8 weeks, 643*
Phenothiazine derivatives
Effect of, on swine, 488
Pig starter rations
Rations of skim milk and whey for, 1055
Pituitary glands
Growth hormone of, from dwarf calves, 810
Pork muscle
Effect of mineral supplement on, color, 1195
Effect of ration on properties of, 404
Physical and chemical characteristics of, 214
Pork quality
Physical, chemical and organoleptic relationships, 145
Post-natal growth
Early, in merino sheep, 1208
Potassium
Effect of high, ration on lambs, 127
Pregnancy
Maintenance of, with gonadal hormones, 114
Proceedings
51st Annual National meeting, 313
Progestational compounds
Orally effective, 412
Progesterone
Effects of, on ewe, 646*
Exogenous, on corpora lutea, 101
Influence of, on post-partum activity, 674
Progesterone and estrogen
Use of, in control of reproductive activities, 1132
Progesterone and estradiol
Effect of, on swine, 898
Protein
Effect of energy on requirement of, in lambs, 1049
Effect of level on swine, 887, 943, 1115
Effect of varying intake of, on swine, 67
Estimating in steer carcasses, 1190
Soybean oil meal as source for swine, 902

R

Rabbit feeder
For digestion studies, 474
Ratio of grain to body weight
Increasing versus constant, on growth, 968*
Recovery interval
Of grazed irrigated forage, 981
Reproduction
Influence of feeding level on, in swine, 274
Reproductive activity
In cycling and anestrous ewe, 607
Variation in post-partum, in Herefords, 238
Reproductive phenomena
Effect of feed treatment on, of ewes, 959
Rescue grass
Livestock production with, 649*
Reserpine
Effect of, on swine, 488

Restricted feeding
Effect of, on age at puberty, 687
Roughage: concentrate ratio
Effect on gains of lambs, 968*
Effect on ration utilization, 910
Rumen bacteria
Cellulolytic fraction of, 1098
Rumen fermentation data
Prediction of forage nutritive value from, 545
Ruminants
Effects of goitrogens on, 678
Ryegrass pastures for beef cattle, 650*

S

Saliva
Secretion of parotid, in bovine, 961*
Salt water
Consumption by heifers, 845
Effects on cattle, 961*
Selection for gain in swine
Genotype and plane of nutrition, 434
Selenium
Counteracting poisoning with arsanilic acid, 260
Effect on muscular dystrophy, 620
Semen
Boar spermatozoa influenced by freezing, 926
Concentration of sperm in boar, 20
Effect of volume of, on embryo survival, 1081
Frozen, from beef bulls, 947*
Seasonal changes in, of rams, 208
Serum proteins
Of beef cattle as affected by alfalfa and fat, 970*
Of parakeratotic pigs, 580
Sex-influenced performance
Measurement and affecting, of swine, 1036
Shade
Effectiveness on growth of swine, 429
Shearing ewes prior to breeding 652*
Silage and hay
Comparative value for weaner calves, 968*
Silo
Miniature, for silage investigations, 198
Slaughter calves, production of, 203
Soybean oil meal
For successive generations of swine, 902
Space allotment for growing swine, 971*
Specific gravity
As measure of beef eating quality, 167
Sperm number
Effect of, on embryo survival, 1081
Estimating in boar semen, 20
Spermatozoa
Motility of, as influenced by freezing semen, 926
Spiramycin
Effect on young pigs, 938
Spring lambs
Selection indexes for weanling traits, 134
Stabilized white grease in baby pig diet, 709
Stilbestrol (see diethylstilbestrol)
Breeding performance of mice fed, 647*
Effect of, in altering steer carcass, 990
Effect of, on swine, 898
Steer response to multiple implants, 966*
Stillbirths in three breeds of swine, 881
Stomach growth
Relation of, to age of lamb, 960*
Succinoxidase activity
Of heart and muscle of cattle, 651*
Suffolk- and Southdown-sired lambs under range conditions, 493
Swine breeding
Problems and evidence in, 75
Swine selection indexes
As indicators of carcass merit, 1024

T

Tapazole
Goitrogenic activity of, 553
Influence of, on fattening steers, 645*
Temperature
Steers in high, environment, 60
Terramycin for steers, 965*
Testosterone
Effect of, on semen, 509
Response of pigs to, 646*
Thyroid activity
Metabolic rate and, in ruminants, 678
Thyroprotein
Supplementation of pig starter, 477
Thyroxine
Serum binding of, 962*
Timothy hay
Value as affected by fertilization, 695
Trace minerals
Effect of, on lambs, 1031

Tranquillizers
Effect of feeding, to swine, 1110
Effect of, on fattening lambs, 639
Effect of, on fattening steers, 533
Effect of, on in-transit shrink, 964*
Effect of, on lambs, 1031
For cattle going to slaughter, 964*
For steers, 965*
Trapazole for steers, 965*

U

Ultrasonic reflections
Measurement of loin eye muscle by, 786
Techniques in evaluating fatness and leanness, 381
Urea utilization by lambs, 44
Urinary calculi in fattening steers, 595
Uterine horn pregnant
Effect of, on birth weight, 470

V

Vitamin A and carotene
Injection of, and blood levels, 961*
Vitamin E
Effect on muscular dystrophy, 620

W

Wallows
Effectiveness on growth of swine, 421
Shaded and unshaded, 921
Water spray
Effectiveness on growth of swine, 421
Weight losses in new-born calves, 963*
Weights of beef calves
Influence of factors on, at 60–240 days, 1062
Winter pasture
Fattening lambs on, 653*

Y

Yeast
Influence of, in wintering ration, 967*

Z

Zinc
Interrelationships between Ca, Fe, Cu and, for swine, 249

AUTHOR INDEX FOR VOLUME 19, 1960

Note: Sectional (Southern and Western) meeting abstracts, by page, are identified by an asterisk. National meeting abstracts, by number, have a separate index at the end of that group of abstracts.

A

Alexander, R. A., 648*
Allen, A. D., 150
Allen, R. S., 1172
Alsmeyer, W. L., 932
Anderson, D. E., 790
Anderson, G. C., 44
Anderson, K. L., 388
Andrews, F. N., 421, 429
Asplund, J. M., 709

B

Backus, W. R., 167
Bailey, C. B., 961*
Baird, D. M., 649*, 650*
Baker, Bryan, Jr., 644*
Baker, F. H., 1150
Balch, C. C., 961*
Barnhart, C. E., 643*
Barth, J., 655*
Bass, Billy, 1153
Beacom, S. E., 859
Beardsley, D. W., 646*
Becker, D. E., 629
Beeson, W. M., 38, 226, 363, 533, 1110
Bell, M. C., 754
Benjamin, W. E., 515
Bertun, Patricia, 969*
Bickoff, E. M., 189, 745, 1143
Bingham, R., 643*
Blackmore, D. W., 956*, 959*, 969*
Blake, Joseph T., 560
Blincoe, Clifton, 962*, 963*
Blumer, T. N., 1164
Bogart, Ralph, 960*
Bohman, V. R., 959*
Bond, T. E., 60, 921, 971*
Booth, A. N., 189, 745
Botkin, M. P., 957*
Boulware, R. F., 644*
Boyd, L. H., 652*
Bradford, G. E., 493
Bradley, N. W., 645*
Bratzler, J. W., 1186, 1195
Bray, R. W., 214, 404
Briggs, H. M., 317
Briskey, E. J., 214, 404
Brockman, J. A., Jr., 763
Brothers, Don G., 653*
Brown, C. J., 1062
Brown, L. R., 735, 1172
Brown, Paul B., 650*
Burnett, Earl, 595
Burroughs, Wise, 458, 465, 678

C

Cahill, V. R., 145, 1036
Calhoun, M. C., 474
Campbell, C. D., 44
Carman, G. M., 34
Carmon, J. L., 653, 769
Carpenter, John C., Jr., 650*
Carpenter, J. W., 651
Carter, C. R., 655*
Carter, R. C., 134, 700
Casady, R. B., 967*
Casida, L. E., 101, 114, 175, 238, 295, 470, 674, 687
Cassard, D. W., 845, 961*
Catron, D. V., 484, 800
Chapman, A. B., 1024
Cheng, E. W., 678
Clanton, D. C., 376
Clark, R. T., 450
Cole, J. W., 89, 167, 242, 656*, 726
Combs, G. E., 932, 1153
Comstock, R. E., 75, 84
Connolly, J. D., 474
Conrad, J. H., 226, 363, 421, 1110
Cook, A. C., 502
Cook, C. Wayne, 560
Cooksey, J. H., 1013
Cooper, R. J., 726
Costello, W. J., 26
Cox, R. F., 803
Coxe, P. B., 965*
Craig, H. B., 1164
Crampton, E. W., 538, 545, 859
Crawford, W. P., 648*
Crockett, J. R., 653*
Crookshank, H. R., 595
Crown, R. M., 109, 820
Cullison, A. E., 198, 769
Culver, A. A., 421, 429
Cunha, T. J., 654*
Cupps, P. T., 208, 509

D

Danielson, D. M., 1055
Damon, R. A., Jr., 109, 820, 967
Davey, R. J., 887
Davis, G. K., 648*, 651*
Davis, R. E., 595, 1089
Davison, Kenneth L., 54
Dawson, W. M., 502
Day, B. N., 898
Deans, R. J., 381
Deatherage, F. E., 145
Dehority, B. A., 1098
Diaz, F., 800
Dinkel, C. A., 260, 948
Donefer, E., 538, 545, 859
Doty, John, 966*
Drain, J. J., 715
Draper, H. H., 963*
Drummond, J., 969*
Dunn, J. A., 881
Dyer, I. A., 1009

E

Easley, J. F., 651*
Edlefsen, James L., 560
Elam, C. J., 1089
Ellis, W. W., 959*
Emerson, J. A., 786
England, David C., 962*, 964*, 968*, 969*, 1190
Ensminger, M. E., 434
Ercanbrack, S. K., 958*

Erwin, E. S., 961*, 966*
Ewing, S. A., 458

F

Faulkner, L. C., 665
Feaster, J. P., 654*
Feinstein, L., 119
Fleming, H. P., 1164
Fontaine, W. E., 429
Fontenot, J. P., 127, 652*
Foote, R. H., 20
Foote, W. D., 238, 470, 674
Fowler, Stewart H., 434
Fox, C. W., 970*
Freund, R. J., 651*, 657
Frost, D. V., 140

G

Gaines, J. A., 134, 700
Garrett, W. N., 60, 773, 921, 1123
Garrigus, U. S., 616, 645*
Garwood, V. A., 429
Gay, N., 1150
Geer, J. C., 644*
Gilbreath, R., 651*
Givens, C. S., Jr., 134
Glenn, M. W., 959*, 960
Godbey, E. G., 203
Godley, W. C., 203
Golumbic, C., 119
Goode, Lemuel, 643*
Gorman, John A., 956*
Gossett, J. W., 646*
Gossett, W. H., 970*
Graham, J. B., 651*, 657*
Graham, Paul P., 645*
Grainger, R. B., 1150
Greig, John, 458
Grummer, R. H., 214, 274, 404, 568, 580, 709
Guillot, Edmond, 644*
Gutierrez, J., 1089

H

Hafs, H. H., 20
Hahn, LeRoy, 971*
Hale, O. M., 646*
Hale, W. H., 590, 648*
Ham, W. E., 1009
Hamilton, J. J., 655*
Hamilton, J. W., 959*
Hanke, H. E., 639
Hansard, Sam L., 655*
Hardie, W. B., 648*
Harris, L. A., 665
Hartman, D. A., 780
Hartman, Glenn, 968*
Hartman, P. A., 735
Hauser, E. R., 238, 470, 674
Haverland, L. H., 845, 961*
Hawbaker, J. A., 800
Hays, Orville E., 274
Haus, V. W., 484, 800, 938
Heitman, Hubert, Jr., 164, 971*
Hemstrom, M. L., 376
Henderson, C. R., 916
Hendrickson, A. P., 189, 745
Hendrickson, R. L., 26
Henneman, H. A., 607
Henricson, B., 1002
Henry, W. E., 1195
Hentges, J. F., Jr., 648*, 654*
Hess, E. A., 926
Hilston, N. W., 959*, 960*
Hiner, R. L., 887
Hironaka, R., 963*
Hiser, R. G., 965*
Hodge, D. E., 38
Hoefer, J. A., 249
Hoekstra, W. G., 214, 404, 568, 580, 620
Hogue, D. E., 1049
Holland, L. A., 722, 970*
Hopkins, H. A., 652*
Hopson, J. D., 910
Hoskins, Fred H., 655*
Hoversland, A. S., 265, 959*, 969*
Howarth, J. A., 164
Howes, J. R., 654*
Hoxsey, Vic, 959*
Hubbert, Farris, Jr., 970*
Hudman, D. B., 477, 943, 1055
Hughes, E. E., 965*
Hull, J. L., 283, 981, 1204

I

Ittner, N. R., 156

J

Jacobson, N. L., 735, 1172
Jensen, A. H., 629
Jessup, Gordon L., Jr., 960*
Jeter, D. L., 226
Johns, D. M., 655*
Johnson, D. D., 763
Johnson, R. H., 735, 1172
Johnson, Ronald R., 522, 1098
Jones, J. G., 5
Jones, J. H., 595, 965*
Jones, J. R., 1049
Jones, L. J., 283
Jones, W. L., 948
Joppa, Leonard, 968*
Jordan, R. M., 515, 639
Joyce, J. A., 910
Judge, M. D., 145
Juhl, Eldon, 183

K

Kamstra, L. D., 867
Kastelic, J., 963*
Keating, F. E., 595
Keck, E., Jr., 1186
Kelly, C. F., 60, 921, 971*
Kelly, R. F., 645*
Kennick, W. H., 1190
Kercher, C. J., 959*, 960*, 964*, 965*, 966*
Kincaid, C. M., 89, 700, 726
Kiracofe, G. H., 646*
Kirk, W. G., 648*, 651*
Klosterman, Earle W., 522
Knapp, Bradford, Jr., 502
Knox, J. H., 970*
Koger, M., 932
Kohler, G. O., 189
Kolari, O. E., 1041
Krueger, Hugo, 963*
Kuhn, John, 970*
Kulwich, R., 119
Kunkle, L. E., 145
Kwong, E., 1115
Kyzer, E. D., 203

L

Laben, R. C., 509
Lang, R. L., 960*
Larsen, L. M., 601, 969*
Lasley, J. F., 150, 898
Lassiter, J. W., 647*, 754, 769
LeFevre, C. F., 867
Lesperance, A. L., 959*
Lickley, Charlene R., 957*

Lindahl, I. L., 873
Lindley, C. E., 1132
Linkenheimer, W. H., 763
Livingston, A. L., 189, 745
Lloyd, L. E., 538, 545, 859
Lofgreen, G. P., 156, 392, 773, 981, 1123, 1204
Loggins, P. E., 653*
Long, Sidney J., 644*
Loosli, J. K., 1071, 1115
Loy, R. G., 175
Lucker, J. T., 655*
Ludwick, T. M., 926
Luecke, R. W., 249
Luther, H. G., 590

M

Madsen, M. A., 852
Maner, J. H., 643*
Manning, R. L., 970*
Marchello, J. A., 956*
Marion, P. T., 645*, 965*
Marlowe, Thomas J., 647*, 651*, 657*, 810
Mason, R. W., 962*, 970*
Matsushima, J., 376
Matthews, D. J., 803, 852
Menzies, C. S., 910
Merkel, R. A., 803
Mestanza, W. M., 652*
Meyer, James H., 5, 156, 283, 773, 981, 1123, 1204
Miller, E. R., 249
Miller, J. I., 715
Miller, R. W., 127
Milstrey, R. A., 763
Minyard, J. A., 260, 948
Mohler, M. T., 533
Moxon, A. L., 522
Mullins, A. M., 644*

Mc

MacVicar, Robert, 127
McCall, J. T., 648*, 653*, 1153
McCampbell, H. C., 649*, 650*
McCormick, W. C., 646*
McCraine, S. E., 820
McCullough, M. E., 649*
Mc Gowan, B., 208
McLaren, G. A., 44

N

Neeley, Betty D., 655*
Nellor, John E., 412, 607
Nelms, G. E., 957*, 966*
Neville, W. E., 650*
Nicholls, O. L., 965*
Nicholson, J. W. G., 1071
Noffsinger, T. L., 421, 429
Noland, P. R., 67
Norton, H. W., 616

O

Odell, G. V., 26
Ogilvie, M. L., 981
Oldfield, J. E., 601, 963*, 969*, 970*
Olson, O. E., 260
Orme, L. E., 89, 167, 656*, 726
Otagaki, K. K., 392
Overby, L. R., 140
Oxley, J. W., 959*, 960*, 965*

P

Palmer, A. Z., 651*
Park, R. L., 715
Parker, Lawrence C., 956*, 958*
Parsons, A. R., 645*
Patterson, E. L., 763
Patterson, J. W., 655*
Patterson, L. C., 965*
Peacock, F. M., 648*, 651*
Pearson, A. M., 381, 786
Peo, E. R., Jr., 477, 943, 1055
Perry, T. W., 533, 1031
Pfost, H. B., 381
Phillips, P. H., 404, 568, 580, 620, 709
Phillips, Sherman A., 650*
Pickett, R. A., 1110
Pipes, G. W., 553
Plumlee, M. P., 38, 226
Pond, W. G., 488, 780, 881, 1115
Pope, A. L., 620
Poulton, B. R., 695
Premachandra, B. N., 553, 1181
Price, D. A., 958*
Price, J. F., 381, 786
Priode, B. M., 700

Q

Quesenberry, J. R., 450

R

Rahlmann, D. F., 208, 509
Raleigh, Robert J., 967*
Raun, Arthur, 465
Raun, A. P., 678
Raun, Ned, 465
Ray, Maurice L., 651*
Reddon, A. R., 208, 509
Reineke, E. P., 607
Rempel, W. E., 84
Repp, W. W., 970*, 971
Reuber, H. W., 26
Reynolds, P. J., 873
Reynolds, W. M., 590, 648*
Richards, C. R., 474
Richardson, D., 910
Riddle, K. H., 957*
Rigor, E. M., 687
Ritchie, H. D., 249
Roberts, S. J., 881
Robertson, G. L., 644*
Robinson, N. W., 655*
Robison, O. W., 1013, 1024
Rogers, S. N., 388
Roubicek, C. B., 966*, 970*
Ruliffson, W. S., 388
Rupnow, E. H., 1009
Rutledge, E. A., 902

S

Saffle, R. L., 242
Safford, J. W., 265
Salmela, A. B., 84
Salsbury, S. W., 957*
Schoonover, C. O., 957*
Scott, Harold W., 522
Scott, K. W., 67
Searle, S. R., 916
Self, H. L., 101, 114, 274, 295, 687, 1013, 1081, 1024
Sell, O. E., 649*, 650
Sewell, R. F., 643*
Shawver, C. B., 656*
el-Shazly, Khaled, 1098
Shelby, C. E., 450
Shelton, Maurice, 302, 368
Sherman, W. C., 590, 648*
Shirley, R. L., 651*
Singletary, C. B., 820
Smith, E. F., 388
Smith, G. S., 44
Smith, I. D., 568, 580
Speer, V. C., 484, 800, 938

Spies, H. G., 101, 114, 274, 295, 687
Stanley, Marion, 957*
Stevenson, J. W., 887
Stonaker, H. H., 665, 957*
Stratman, F. W., 1081
Stratton, P. O., 957*, 959*, 960*
Suitor, A. E., 967*
Sutherland, T. M., 957*

T

Tallis, G. M., 1208
Taylor, Billie G., 971*
Taylor, Bruce, 966*, 970*
Taylor, J. C., 645*, 700
Taylor, Norton O., 964*, 968*
Teague, H. S., 902, 926
Terrell, R. N., 656*
Terrill, S. W., 629
Theurer, Brent, 548
Thomas, O. O., 966*, 968*
Thrasher, D. M., 644*
Torell, D. T., 493
Trenkle, Allen, 465
Tribble, L. F., 898
Tsien, W. S., 910
Turkheimer, A. R., 20
Turner, C. W., 553, 1181

U

Ullberg, S., 1002, 1132
Ullrey, D. E., 249
Urick, J. J., 956*

V

Van Arsdel, Wm. C., III, 963*
Van Horn, H. H., Jr., 735
Van Horn, J. L., 959*, 968*, 969*
Van Stavern, Jack, 522
Van Vleck, L. D., 916
Varnell, T. R., 961*, 970
Vegors, H. H., 655*
Vetters, R. L., 616

W

Wade, M. A., 959*
Wagner, J. F., 607
Wahlstrom, R. C., 183
Wall, M. W., 965*
Wallace, H. D., 643*, 932, 1153
Wallace, Joe D., 967*
Wallentine, M. V., 715
Warner, Fay T., 651*
Warner, R. G., 1071
Warnick, A. C., 643*, 654*
Warren, E. P., 653*
Watkins, W. E., 971*
Weeth, H. J., 845, 961*, 962*
Weider, Kraig, 962*
Weir, W. C., 208, 283, 493, 773
Welch, J. A., 44
Welch, James G., 620
Wheat, J. D., 722, 803
Wheeler, R. F., 203
White, P. E., 649*
White, R. L., 959*
Whitehair, C. K., 127
Whiteman, Joe V., 653*
William, J. P., 881
Williams, L. W., 656*
Wilson, C. B., 959*
Wilson, L. O., 958*
Woelfel, C. G., 695
Woods, Walter, 54, 458
Woodward, R. R., 450
Woolfolk, P. G., 652*

Y

Yoerger, R. R., 1186
Young, D. C., 20
Young, V. A., 388

Z

Zimbelman, R. G., 175
Zimmerman, D. R., 101, 114, 295, 484, 687
Zobrisky, S. E., 898

INFORMATION FOR CONTRIBUTORS

1. Papers may be submitted reporting work whose ultimate objective is clearly the solution of a livestock production problem and whose contents should be of interest particularly to those dealing with livestock production problems. Review papers on subjects of general interest will also be published at intervals, and will be prepared on invitation by the Editorial Board.

2. All papers will be subject to critical review by the Editoral Board, or others designated by the Editor. Papers needing revision will be returned to authors and should be revised and returned promptly. Papers not suitable for publication will be returned to authors with a statement of reasons for not accepting them.

3. Papers submitted should be based on new and adequate information. The primary purpose of a scientific publication is to provide information based on well-described data and to exchange ideas. Authors are therefore discouraged from submitting for publication results of research involving products whose ingredients cannot be disclosed. Information on composition and source of any product which may have a bearing on the experimental results should be provided. Consult a recent issue for style and form. The following are guides:

(a) Manuscripts must be typed, double-spaced and the ribbon copy submitted. Submission of two copies (one carbon) will facilitate review.

(b) All pages, including those of tables and legends, must be numbered. The lines of the text, but not of tabular material or "Literature Cited", must be numbered in the left margin, beginning with one at the top of each page.

(c) Tables should be as few and as simple as is feasible for presentation of the essential data. Each table should be on a separate sheet.

(d) Legend for each figure should be typed on a separate sheet. Photographs should be carefully prepared and labeled. Magnification of photomicrographs should be indicated on legends. Charts should be prepared in India ink. Typed material on charts is not acceptable. Material that will not reproduce satisfactorily will be returned for revision. For suggestions on preparing illustrative material see the "Style Brief" published by the Wistar Institute Press, Philadelphia. If in doubt, consult the Editor before putting material in finished form.

(e) The introduction should consist only of a paragraph indicating very briefly the nature of the question asked and the reason for asking it. Reference to relevant literature should be made later in the discussion of the results. Concise presentation of data is desired and there should be evidence of statistical examination wherever obviously useful in the interpretation. Unsupported hypotheses should be avoided. The organization of a manuscript may vary with the nature of the material, but all manuscripts should contain a clear statement of application of the results or their relation to some problem of the livestock industry. Each paper should end with a brief summary in the form of an abstract containing the most pertinent data in the briefest possible form.

(f) Literature citations must be listed in alphabetical order and should be referred to in the text by author and date, i.e., Castle (1924), or (Castle, 1924). Citations may be referred to by number in review articles where the number

of citations is too great to permit convenient use of the above form. "Literature cited" lists should be typed in a style used in a current issue of the JOURNAL.

4. Manuscripts will be edited in the order received, and accepted papers will be published as nearly in this order as feasible.

5. There will be a charge for making engravings in excess of one page per paper and of printing tables in excess of two pages per paper. The author will be asked when his manuscript is accepted to indicate the institution, agency or individual that will assume responsibility for the charges and for the reprints ordered at that time.

6. Authors will receive galley proof of articles together with a form for supplying an abstract for "Biological Abstracts." *Corrected proof and abstract should be mailed to the Editor within three days after they are received. Failure to do this may result in delay of publication until the next issue.*

7. One author of each manuscript should be a member of the Society. Papers by non-members can be published only after approval by the Executive Committee.

8. A "News and Notes" section will be published in each issue, including Society announcements, changes in positions and other items of professional interest to members. All such items should be sent promptly to the Editor.

9. Abstracts of papers to be presented at the annual meetings of the Society will be published in the November issue. Such abstracts must not exceed 250 words in length, should be typed (double spaced) and the ribbon copy submitted, the lines on the page should be numbered, in the left margin, from top to bottom, and must be in the hands of the Secretary of the Society by August 15, preceding the meeting. These abstracts must be summaries of results and conclusions.

10. Presentation of a paper at the annual meeting does not exclude it from publication in complete form in the JOURNAL. Such papers may be submitted to the Editor and will be given equal consideration with others submitted.

11. All manuscripts and correspondence concerning them should be addresed to the Editor: W. D. Gallup, Department of Biochemistry, Oklahoma State University, Stillwater, Oklahoma, or to the publisher: Boyd Printing Company, Inc., 49 Sheridan Ave., Albany 10, N. Y.

12. All correspondence concerning subscriptions to the JOURNAL OF ANIMAL SCIENCE and other business matters should be addressed to the Business Manager, C. E. Terrill, Animal Husbandry Research Division, Agricultural Research Center, Beltsville, Maryland, or to the publishers, Boyd Printing Company, Inc., 49 Sheridan Avenue, Albany 10, N. Y.